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District of Kenora, Patricia Portion

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Foreword

The North Spirit Lake – MacDowell Lake metavolcanic–metasedimentary belt and adjacent granitic rocks contain occurrences of gold, copper, lead, zinc, molybdenum, nickel, and silver. Until 1971, the geological map coverage was at a reconnaissance level and dated back to 1938. A series of detailed mapping projects was therefore initiated to provide a more effective basis for determining the mineral potential of the region and for guiding exploration. The MacDowell Lake area report is the third and last report of this series.

V.G. Milne

Director
Ontario Geological Survey

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MAP (back pocket)

Map 2497 (coloured) — MacDowell Lake Area, Kenora District.
Scale 1:31 680 or 1 inch to 1/2 mile.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Geology of the
MacDowell Lake Area
District of Kenora, Patricia Portion

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Abstract

The MacDowell Lake area (Figure 1) encompasses about 255 km² and is located about 160 km NNE of Red Lake. The map-area is underlain by Early Precambrian (Archean) rocks which may be assigned to two broad rock associations: a metavolcanic–metasedimentary association, and a batholithic granitic intrusive rock association.

The metavolcanics range in composition from mafic to felsic; a large proportion of the more felsic rocks are pyroclastic in origin. The metasediments consist of conglomerate, sandstone, mudstone, and chert and interlayered ironstone. Mafic and intermediate rocks intruded the volcanic and sedimentary strata. All of these rocks were subsequently folded and metamorphosed, locally to high grade. Batholithic granitic rocks intruded the supracrustal and associated rocks, and now outcrop to the east and west of them.

Fold structures within the area are difficult to unravel because of low outcrop density which also inhibits the establishment of a stratigraphic framework for the supracrustal rocks. Major northwest–trending faults are present, particularly in the western part of the area. Northeast–trending faults are also present.

The area has potential for base metals and gold; at two localities, near Tahoe Lake and near Shrimp Lake, there is evidence of alteration which may be related to economic mineralization.

Résumé

La région du lac MacDowell (Figure 1) occupe une superficie d'environ 255 km² et est située à quelque 160 km au NNE de Red Lake. La région cartographiée recouvre des roches précambriennes inférieures (archéennes) que l'on peut classer en deux associations: une association de roches volcaniques et sédimentaires métamorphisées et une association de roches intrusives granitiques batholitiques.

La composition des roches volcaniques métamorphisées varie des roches mafiques aux roches claires; une partie importante des roches claires étant d'origine pyroclastique. Les roches sédimentaires métamorphisées sont formées de conglomérat, de grès, d'argile et de minerai de fer chaille et interstratifié. Les roches mafiques et neutres ont fait intrusion dans les strates volcaniques et sédimentaires. Toutes ces roches ont ensuite été plissées et métamorphisées par contact, élevant du même coup leur teneur. Les roches granitiques batholitiques ont fait intrusion dans les roches supracrustales et associées et affleurent maintenant du côté est et ouest.

Il est difficile d'identifier les structures de pli en raison de la faible opacité des affleurements qui ne permet pas d'établir le réseau stratigraphique des roches supracrustales. On note la présence d'importantes failles orientées nord–ouest, surtout dans la partie ouest de cette région, et de failles orientées nord–est.

Cette région pourrait être riche en métaux de base et en or. Près de Tahoe Lake et de Shrimp Lake, on note des signes d'altération pouvant être liés à la minéralisation commerciale.

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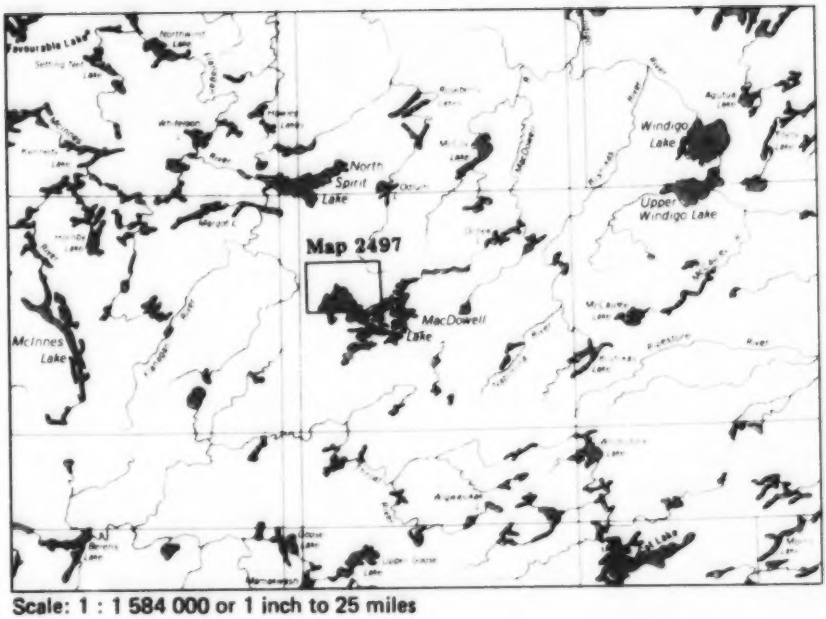

Scale: 1 : 1 584 000 or 1 inch to 25 miles

Figure 1. *Key map showing location of MacDowell Lake area.*

Introduction

Location and Means of Access

The MacDowell Lake map–area is located about 160 km NNE of Red Lake in the Patricia Portion of the District of Kenora. It comprises two adjoining rectangular areas. The more northerly is 205 km² in extent and is bounded by Latitudes 52°21'30"N and 52°15'N and by Longitudes 92°55'W and 92°40'W. The more southerly area is approximately 49 km² in extent and is bounded by Latitudes 52°15'N and 52°12'N and Longitudes 92°45'W and 92°35'W.

The only efficient means of access is by float–equipped aircraft (nearest charter bases are at Red Lake and Cochenour). Many of the lakes within the area are suitable for use by float–equipped aircraft; there are only a few parts of the area more than 3 km from any such lake.

Fieldwork

Geological mapping of the area at a scale of 1 inch to 1/4 mile was done during the summer of 1975.

Basemaps were prepared by the Surveys and Mapping Branch of the Ministry of Natural Resources from Forest Resources Inventory maps. Aerial photographs at a scale of 1:15,840 obtained from the Silviculture Section of the Ministry were used in field mapping. During the field season supplementary air photographs, provided by the Northwestern Region of the Ministry of Natural Resources, were used as an aid in the interpretation of the older (1955) silviculture air photos some of which were of only marginal use in the field because of radical vegetation changes brought about by recent forest fires.

The shorelines of most lakes and most outcrops shown on the air photos were mapped.

Acknowledgments

In 1975 senior assistant on the project was H.L. Gibson; junior assistants were T. Carter, P.C. Clark, and M.M. Torzsok; the enthusiastic and capable help of these assistants is appreciated. About 45 percent of the mapping was done by Mr. Gibson and 10 percent by Mr. Carter. Tne many courtesies extended by personnel of Sabourin Lake Airways of Cochenour, Ontario, are gratefully acknowledged. Mining company reports filed in the office of the Resident Geologist, Ministry of Natural Resources, in Red Lake, were used by the author in the reconstruction of the history of exploration within the map–area. The co–operation of W. Valiant, former assistant to the Resident Geologist in Red Lake, and other personnel of the Ministry of Natural Resources in Red Lake is gratefully acknowledged.

Previous Geological Work and Prospecting Activity

Although Hurst (1930) mentioned the prospecting of greenstones which outcrop in the vicinity of Spirit (Fairy) (North Spirit) Lake, a geological report on the North Spirit Lake area by J.D. Bateman (1939) was the first extensive work on the geology and exploration of the area. The field work for Bateman's report was done in 1937 and served to define "a sedimentary–volcanic belt, extending southeast of North Spirit Lake, through Hewitt Lake to MacDowell Lake, a distance of 22 miles and averaging 5 to 8 miles in width" (Bateman 1939, p.45).

In 1960 and 1962, the Geological Survey of Canada did reconnaissance mapping of NTS area 53C within the boundaries of which the Hewitt Lake area is located (Donaldson 1961; 1969). This mapping did little to change Bateman's (1939) map. The sedimentary rocks of the North Spirit Lake area were studied in considerable detail by Donaldson and Jackson (1965) who described the rocks, discussed associated problems, and made suggestions for further work. In 1972 and 1973 the author mapped the Hewitt Lake area immediately to the north of the present map–area (see Wood 1980). The area to the north of the Hewitt Lake area — the North Spirit Lake area — was mapped in 1971 (see Wood 1977).

Mineral Exploration

Activity in the general region began in the 1920s and was documented by J.D. Bateman (1939) who mapped the North Spirit Lake – MacDowell Lake area at a scale of 1 inch to 1 mile.

The present map–area encompasses the southern end of the North Spirit Lake – MacDowell Lake metavolcanic–metasedimentary belt. Summaries of the mineral exploration in that part of the metavolcanic–metasedimentary belt north of the present map–area can be obtained from previous publications of the author (Wood 1977, 1980).

Within the present map–area, mineral exploration has been minimal. No exploration activity was reported by Bateman (1939). Data in the files of the Resident Geologist, Ministry of Natural Resources, Red Lake, indicate exploration activity as follows.

In 1967, Madsen Red Lake Gold Mines Limited performed work on an exploratory licence issued by the Ontario Department of Mines for the purpose of investigating the iron content of the beach sands and the unconsolidated material on the bottom of MacDowell Lake. The approximately rectangular area covered by the licence extended from close to Mattson Lake SSE to the most southerly extension of MacDowell Lake, encompassing some 8,400 acres (34 km^2) of water. Sand ridges on the lake shore were trenched and sampled; holes were systematically drilled through the lake ice and bottom samples retrieved where magnetite was found to be present; and 17 holes totalling 629.0 feet (191.7 m) were washed to bedrock. It was found that the beach and lake bottom sands varied considerably in composition, grain size, and colour, and that the magnetite content varied from zero to over 10 percent. In general, it was observed that the iron–bearing sands occurred in very thin beds, the amount of magnetite decreased with depth below lake bottom, and the magnetite content was independent of other variables. The study concluded that it was not economically feasible to recover the low grade magnetite from the bottom and beach sands.

In 1969, Noranda Exploration Company Limited performed airborne magnetic and electromagnetic (Mark V INPUT) surveys of a 24–claim group whose eastern edge overlapped the western end of Atikamik Lake. Two 6–channel anomalies were recorded, one with magnetic correlation, and one without magnetic correlation. There is no record of further work on the claims.

In 1970, Selco Exploration Company Limited diamond drilled five holes totalling 669.5 feet (204.1 m) on a 13–claim group held by R. Green. Granitic rocks and metasediments were encountered in all of the drill holes and gabbro was encountered in one hole. Streaks and blebs of pyrite and pyrrhotite were encountered in all of the drill holes. Specks and veinlets of chalcopyrite were reported in two of the drill holes. The mineralization appears to have been con-

tained in metasediments, which, from the descriptions given in the drill logs, may be sulphide–facies iron formation. No assay results were given, and there is no record of further work on these claims.

As of December 1975 there was only one claim in good standing within the confines of the map–area.

Topography and Drainage

That part of the map–area northwest of the Lac Seul Moraine and west of the longitude of the eastern part of Mattson Lake is drained by the Flanagan River System which flows into Sandy Lake. From there drainage is to Hudson Bay by the Severn River. That part of the map–area southeast of the moraine, excepting the area in the vicinity of Atikamik and Armstrong Lakes, is drained by the MacDowell River (not shown on the map, it drains from the east end of MacDowell Lake) which joins the Severn River east of Sandy Lake. The Atikamik and Armstrong Lakes area is drained by the Roseberry River System which flows into Sandy Lake.

The relief in the map–area is very low. The highest ground in the map–area, just over 1,200 feet above sea level, is the moraine. The lowest part, MacDowell Lake, is just below 1,100 feet (see NTS sheet 53C). The moraine relief is therefore just over 100 feet. Swamps are a dominant feature of the landscape; the size of many natural swamps and the number of swamps has been greatly increased due to the damming of streams by the ubiquitous beaver.

As a corollary to the low relief, most of the rock outcrops in the map–area are two dimensional. Due to the Pleistocene glaciation most outcrop surfaces are smoothly polished.

Natural Resources

Tree types in the area include jackpine, spruce, poplar, balsam, and tamarac. Much of the forest is immature due to the ravages of forest fires which up to the year of fieldwork, went uncontrolled. The moraine that extends across the area hosts a good growth of jackpine, which, in general, grows preferentially on sandy soil. Near the outlet of Annas Lake a stand of mature trees with trunks up to about 70 cm in diameter was noted.

The author does not know of any attempts at agriculture in the map–area, however the most suitable parts of the area would be those underlain by well drained Pleistocene sediments.

Should industrial development take place within the map–area, local Pleistocene deposits, in the moraine in particular, would offer potential as aggregate sources. It is worth noting that the land with best potential aggregate sources, agricultural capabilities and building site suitability is underlain by Pleistocene deposits. Before such ground is extensively developed for any one purpose, consideration should be given to the others.

Within the area mapped the potential for hydro–electric power development is negligible. Damming of streams to create an artificial head of water would result in widespread flooding because of the low overall relief of the area.

General Geology

The MacDowell Lake area covers the southern extremity of the northwest–striking North Spirit Lake – MacDowell Lake metavolcanic–metasedimentary belt which is located in the Gods Lake (Sachigo) Subprovince; the granitic rocks in the southwestern part of the map–area are in the Berens River Subprovince of the Superior Province of the Canadian Shield (see Ayres *et al.* 1971). The metavolcanics and metasediments are bounded to the west by a fault structure that has juxtaposed them and batholithic granitic rocks; this fault separates the Gods Lake (Sachigo) and Berens River Subprovinces. To the east, batholithic granitic rocks are intrusive into the supracrustal rocks. Between Armstrong and Atikamik Lakes this intrusive contact strikes in a northwesterly direction; between Armstrong Lake and the northern part of MacDowell Lake it strikes in a northeasterly direction. Near MacDowell Lake the contact intersects faults that parallel the western boundary fault. In the southeastern part of the map–area there is a narrow, fault–bounded graben containing metavolcanics and metasediments that are an extension of the main belt. The supracrustal rocks decrease in age away from the intrusive granitic contact. The metavolcanics and metasediments are intruded by a stock of intermediate composition and sills of mafic composition.

Pleistocene and Recent deposits cover a large portion of the land surface. There is a southwest–trending moraine in the northern part of the map–area.

The supracrustal rocks within about 1–1.5 km of the southern and eastern granitic contacts are of medium to high metamorphic grade (Winkler 1974). In the rest of the map–area the metavolcanics and metasediments are low grade except for some local medium–grade occurrences near the western fault contact.

EARLY PRECAMBRIAN (ARCHEAN)

METAVOLCANICS

All of the volcanic rocks in the map–area have been metamorphosed, and are therefore referred to as metavolcanics. They constitute a volumetrically important part of the North Spirit Lake – MacDowell Lake metavolcanic–metasedimentary belt. The metavolcanics have been broadly classified as either mafic or intermediate to felsic (see Table 1 and Map 2497, back pocket). Further subdivision has been made on a textural basis.

The mafic metavolcanics weather a mid–to–dark green to almost black in outcrop; inspection of the weathered crust generally reveals the presence of feldspathic minerals but no quartz. Silica content is between 45 and 55 percent (see "Chemistry of the Metavolcanics").

The felsic to intermediate metavolcanics are light coloured (buff) in outcrop, generally black on fresh surface, often contain recognizable phenocrysts of quartz and/or feldspar, do not contain large amounts of mafic minerals, and contain more than 55 percent silica (see "Chemistry of the Metavolcanics").

Within the map–area the felsic to intermediate metavolcanics are the more plentiful.

Mafic Metavolcanics

Mafic metavolcanics occur in four parts of the map–area near (1) Nipa Lake, (2) Tahoe Lake, (3) the east and southeastern contact of the supracrustal and granitic rocks, and (4) in the southeastern graben extension of the belt.

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE MACDOWELL LAKE AREA.

CENOZOIC

QUATERNARY

RECENT

Fluvial, lacustrine, and swamp deposits.

PLEISTOCENE

Till, lacustrine deposits (bedded sand, silt and clay); outwash deposits (boulder gravel to silt).

Unconformity

EARLY PRECAMBRIAN (ARCHEAN)

FELSIC AND INTERMEDIATE INTRUSIVE ROCKS

POST BATHOLITHIC INTRUSIVE DIKE ROCKS

Quartz-biotite microdiorite.

Intrusive Contact

BIOTITIC BATHOLITHIC INTRUSIVE ROCKS

Biotite (muscovite) quartz monzonite; porphyritic biotite quartz monzonite; leucocratic biotite (muscovite) quartz monzonite; porphyritic leucocratic biotite (muscovite) quartz monzonite; leucocratic muscovite-garnet-biotite quartz monzonite; pink, quartz-feldspar pegmatite; white, muscovite-garnet pegmatite; aplite.

HORNBLENDIC BATHOLITHIC INTRUSIVE ROCKS

Hornblende-biotite granodiorite, trondhjemite, minor quartz monzonite; porphyritic hornblende-biotite granodiorite, trondhjemite, minor quartz monzonite; biotite-hornblende granodiorite, trondhjemite, minor quartz monzonite; porphyritic biotite-hornblende granodiorite, trondhjemite, minor quartz monzonite; pink quartz-feldspar pegmatite; aplite.

Intrusive Contact

METAMORPHOSED INTERMEDIATE INTRUSIVE ROCKS

Quartz biotite diorite (porphyry).

METAMORPHOSED MAFIC INTRUSIVE ROCKS

Amphibolite; layered porphyritic gabbro (mafic phenocrysts); gabbro; layered porphyritic gabbro (feldspar and mafic phenocrysts).

Intrusive Contact

METAVOLCANICS AND METASEDIMENTS

METASEDIMENTS

CHEMICAL METASEDIMENTS

Chert; magnetite ironstone; ferruginous chert; sulphide ironstone; para-amphibolite.

CLASTIC METASEDIMENTS

Mudstone: very thin to medium bedded.

Sandstone: lithic arkosic wacke; lithic subarkosic wacke; graded wacke-mudstone; biotite-muscovite schist; muscovite-biotite schist; andalusite schist; cordierite schist; sillimanite schist; garnet schist; garnet-cordierite-cummingtonite schist.

Conglomerate: polymictic orthoconglomerate; polymictic paraconglomerate; orthoconglomerate (metavolcanic and quartz clasts) with sulphide-rich matrix.

METAVOLCANICS

FELSIC TO INTERMEDIATE METAVOLCANICS

Flows; porphyritic (quartz-feldspar) flows; tuff, crystal tuff, lapilli-tuff, lapillistone, tuff-breccia, pyroclastic breccia; garnetiferous flows and pyroclastics.

MAFIC METAVOLCANICS

Flows; porphyritic flows (mafic phenocrysts); calcareous flows; amygdaloidal flows; pillowed flows; mafic tuff, lapilli-tuff, tuff-breccia.

Nipa Lake. Near Nipa Lake, the mafic metavolcanics are of medium to high metamorphic grade and have been strongly deformed so that they are strongly foliated. Bateman (1939) described these rocks as "bedded amphibolite". The rocks are generally equigranular and phaneritic. There are some outcrops of coarse–grained (maximum crystal size, 4 mm) mafic rock considered by the author to be metavolcanic rather than intrusive because of (a) the lack of criteria definitive of an intrusive origin, and (b) the association with much finer grained rocks considered to be volcanic. No pillow structures were observed in any of the mafic rocks.

Minerals observed in thin sections of the foliated equigranular rocks are hornblende and andesine–labradorite, with accessory iron oxides. Some rocks near the granitic contact contain microcline and biotite, presumably as a result of metasomatism from the adjacent granitic rocks.

The coarse–grained rocks have an essentially similar mineralogy (hornblende 52 percent, feldspar 35 percent, sphene 5 percent, epidote 5 percent, opaques 2 percent), but a different texture. They have a foliated, porphyritic (mafic phenocrysts) appearance in hand specimen. In thin section the mafic 'phenocrysts' can be seen to be composite grains of hornblende and sphene. The author considers that the amphibole–sphene clots, which are up to 5 mm long, represent original pyroxene phenocrysts. Hornblende crystals are about 0.7 mm long, plagioclase crystals about 0.2 mm long.

Some 2.6 km southeast of Nipa Lake two outcrops of fine–grained foliated mafic rocks were mapped as metavolcanics. The intensity of foliation is less than in the fine–grained equigranular rocks near Nipa Lake, otherwise there is no apparent difference.

Tahoe Lake. In the vicinity of Tahoe Lake most of the mafic metavolcanics are fine–grained foliated flows without original textural characteristics, but there are also pillowed, amygdaloidal and coarse–grained varieties, as well as some thickly laminated mafic rock considered to be mafic tuff.

The pillow structures were unsuited to top determinations because of locally intense structural deformation. Although the bedding in the mafic tuff is considered to be primary, the possibility of a tectonic origin cannot be ruled out. The volcanic origin of the coarse–grained mafic rocks is suggested because of their association with other undisputed mafic flow rocks.

No thin sectioned samples of mafic rocks from around Tahoe Lake were available at the time of writing. Based on outcrop descriptions the mineralogy of the rocks is similar to equivalent rocks from near Nipa Lake.

Eastern and Southeastern Areas. The largest occurrence of mafic metavolcanics extends from Atikamik Lake along the eastern contact between the supracrustal rocks and the batholithic granitic rocks to MacDowell Lake and southeastwards between Annas and MacDowell Lakes. Throughout the 25 km strike length of this formation the metamorphic grade is medium to high (Winkler 1974). The intensity of deformation varies along the strike length, and is greatest between Armstrong and Annas Lakes. All of the mafic metavolcanics are intensely foliated and in some instances appear to be layered; the layering could be tectonic or an expression of original bedding. Mafic metavolcanics in this part of the area include pillowed, amygdaloidal and carbonate–bearing flows, and rare fine– to coarse–grained pyroclastics.

Near Atikamik Lake and southwest of Armstrong Lake the rocks are foliated, but not intensely deformed. Original textures, such as pillow structures and

pillow breccias are well preserved although in some instances, for example southwest of Atikamik Lake, deformation prevents the determination of stratigraphic top directions from pillow structures. Between Shrimp Lake and the intersection point of the northwestern and northeastern arms of MacDowell Lake, metamorphic recrystallization has been great enough to obscure the original character of the mafic volcanic rocks and the mafic intrusive rocks, thus the two genetically different rocks may be confused. The mafic metavolcanics in the southeastern part of the map–area have been variably deformed and are very strongly foliated to mylonitized in places; others are less strongly deformed such that original pillow structures are recognizable.

From Atikamik Lake to about 2 km southeast of Shrimp Lake the mafic metavolcanics weather dark green or green–black but occasionally mid–green. For example near Atikamik Lake pillow breccias are preserved and commonly parts of the breccia are mid– or even light greyish green. The lighter colouration is probably due to greater amounts of plagioclase and/or epidote.

The mafic metavolcanics in this vicinity are dark grey on fresh surface and are composed essentially of hornblende (about 50 percent), plagioclase (An_{17}, about 43 percent), sphene (about 2 percent), opaques (about 1 percent), with or without epidote (about 4 percent); metamorphic pyroxene is present in some samples and may form several percent of the rock.

The metavolcanics in the southeastern part of the map–area display a range in weathered surface colour from green black in relatively non–sheared outcrops to greyish green in extensively sheared outcrops. The rocks are various shades of grey on fresh surface. The mineralogy as seen in thin section is less monotonous than in the mafic metavolcanics in other parts of the map–area. This is a function of original composition, metamorphism, and deformation. A typical foliated mafic rock here is equigranular with grain sizes from 0.05 mm to 0.5 mm with a mean around 0.25 mm. Plagioclase and amphibole define the foliation. Minerals present are hornblende (50 percent), plagioclase (oligoclase?, 42 percent), clinozoisite (5 percent), sphene (2 percent) and opaques (1 percent).

A thin section of a carbonatized mafic metavolcanics from the eastern side of the long peninsula is composed of clinopyroxene (30 percent), calcite (30 percent), plagioclase (andesine, 27 percent), hornblende (8 percent), garnet (3 percent), and opaques (2 percent). With the exception of carbonate crystals, 0.5–2.0 mm in diameter, that occur in veinlets parallel to the foliation (this is a reflection of their outcrop appearance) the grain size of the minerals ranges from 0.05 mm to 2.0 mm.

A thin section shows that a sheared, layered, mafic rock, thought to be a sheared flow rock, from the long peninsula, is composed of plagioclase (37 percent), hornblende (30 percent), clinopyroxene (augite, 15 percent), epidote (15 percent), and accessories (3 percent). Some layers are more mafic than others, the mafic layers contain anhedral augite (up to 2 mm long), hornblende and epidote (both about 0.10 mm long), whereas the other layers consist of plagioclase, hornblende, and epidote (all anhedral and about 0.10 mm in long dimension).

The mafic tuff exposed in two outcrops on the northeastern part of the long penninsula on MacDowell Lake (see the accompanying map) contains hornblende crystals up to 4–5 mm in maximum dimension. They could have originated as coarse–grained flows or intrusions, that were subsequently intensely deformed. Lapilli tuff outcrops only about 30 m from an outcrop of granitic rock that was mylonitized by a fault passing between the outcrops. There is therefore a

possibility that the fragmental nature of the outcrop of lapilli tuff may be the result of faulting and shearing and subsequent incorporation of a more felsic rock type, such as intermediate to felsic metavolcanics, into a mafic flow.

Inspection of a number of thin sections of sheared mafic rocks from the peninsula on MacDowell Lake suggests that some of the shearing may have predated the peak of metamorphism, because although metamorphic minerals such as hornblende and clinopyroxene are strained and fractured, they are not extensively mylonitized, nor is there an abundance of chlorite which might be expected in rocks that have undergone shearing.

Intermediate to Felsic Metavolcanics

The intermediate to felsic metavolcanics are areally the most important component of the metavolcanic–metasedimentary belt. Both flows and pyroclastic rocks are common in the map–area but pyroclastic rocks predominate. Flows are more common in the vicinity of Tahoe Lake but are present elsewhere. The only pyroclastic rocks that show a preferential distribution pattern are the crystal tuffs which are abundant east and southeast of Mattson Lake. Most of the pyroclastic rocks, particularly the coarse–grained ones, probably originated as lithic tuffs, however, recrystallization and deformation has made any originally vitric fragments indistinguishable from fine–grained lithic fragments.

Flows

All of the flow rocks weather to a light grey or buff colour: the lighter the colouration, the more felsic the rock. On fresh surface the rocks are shades of grey or black. All of the outcrops of flow rocks are small in size, any larger outcrops containing flow–rocks inevitably have associated pyroclastics. As a consequence of the small exposures, the only typifying observation which could be made in the flows was the presence or absence of phenocrysts. Phenocrysts are either quartz or feldspar or in some instances both.

As outlined above, most of the flows occur within about 2 km of Tahoe Lake. In this locality the felsic rocks are tough and splintery on outcrop. This is a reflection of mineralogy in that the rocks are more siliceous than similar metavolcanics in the rest of the map–area. Thin section study indicates that the rocks are fine grained with an average grain size of 0.03 mm. Micro–phenocrysts of quartz, and/or feldspar altered to sericite, reach 0.20 mm in diameter. In several thin sections, small clots up to 0.20 mm long, composed of biotite crystals up to 0.06 mm long, were observed. In other thin sections biotite is uniformly distributed throughout. The fine–grained matrix is made up of quartz, feldspar and muscovite. The thin–sections examined were not stained for feldspar, thus the relative proportions of quartz and feldspar could not be estimated. Two samples which represent the observed compositional extremes contained: quartz + feldspar 70 percent, biotite 20 percent, muscovite 3 percent, opaques 7 percent, and tourmaline less than 1 percent; and quartz + feldspar 63 percent, biotite 10 percent, muscovite 15 percent, opaques 10 percent, and carbonate 2 percent.

Flows in other parts of the map–area are a darker grey and less splintery than those that outcrop around Tahoe Lake. On the islands at the intersection of the two main arms of MacDowell Lake the flows are strongly jointed, with a shallow northeast dip. A thin–sectioned micro–porphyritic sample from south of Shrimp Lake is composed of feldspar and quartz (63 percent), hornblende (20 percent), biotite (15 percent), and opaques (2 percent). The biotite and hornblende crystals define a foliation. Most of the biotite crystals are about 0.03 mm long, al-

though some reach 0.15 mm in length. The opaque minerals are associated with the biotite thereby suggesting that the biotite may have formed by metamorphism from an originally more mafic mineral such as hornblende or pyroxene. The hornblende crystals are about 0.15 m long. Feldspar micro–phenocrysts range in size from 0.40 mm to 0.90 mm and are set in a fine–grained (0.025 mm) quartzofeldspathic matrix.

Samples of flows from other parts of the map–area were not thin–sectioned, but sectioned samples of pyroclastic rocks would suggest that the mineralogy and the textures outlined above, are typical of the intermediate to felsic flows.

Pyroclastic Rocks

With the exception of several outcrops of coarse pyroclastics about 1 km east of the south end of Nipa Lake, all of the pyroclastic rocks along the western margin of the belt are fine grained. In contrast, the pyroclastic rocks in the eastern part of the supracrustal belt, west of Atikamik Lake and north and south of Shrimp Lake are coarse; most outcrops contain lapilli–size components, many outcrops contain block–size fragments. Northeast and southeast of Mattson Lake, and also southeast of Nipa Lake the predominant pyroclastic rock type is crystal tuff.

Area West and South–Southeast of Mattson Lake. Within the fault block that extends from Mattson Lake beyond Annas Lake to the southeast, the pyroclastic rocks are essentially similar in their outcrop appearance and mineralogy. The predominant pyroclastic rock types are tuff and lapilli–tuff. Due to shearing related to fault structures the original characteristics of some rocks are not apparent on outcrop or in thin section. The rocks weather to a mid–grey to grey–green colour. The lapillus–sized fragments are almost always oblong–shaped on horizontal outcrop surfaces. A few outcrops with vertical exposures indicate that the clasts are elongated in a vertical direction. Occasional angular fragments were observed. The author does not interpret these to signify that all ellipsoidal fragments were originally rounded but rather that outcrops with angular–fragments escaped strong penetrative deformation.

The metamorphic grade of the rocks west and south–southeast of Mattson Lake is low except within a few tens of metres of the granitic contact where the grade is medium to high. No thin sections were made of intermediate pyroclastic rocks from the long peninsula on MacDowell Lake, however, examination of the mafic metavolcanics (see above) suggests that the metamorphic grade is medium.

The long axes of fragments define on a macroscopic scale the foliation that is defined on a microscopic scale by the parallel alignment of ferromagnesium minerals. The accompanying map (back pocket) indicates the composition of the lapillus– or block–size fragments relative to the matrix on any particular outcrop. On fresh surface the rocks are grey coloured and in the coarser fragmentals it may be difficult to distinguish fragments from matrix except on weathered surfaces. Beds range in thickness from those too thick to be observed on outcrop, to those that are only a few millimetres thick.

Although individual rocks of this unit are macroscopically distinct because of features such as bedding size and clast size, microscopically they are much alike. This is due to the overall mineralogical and microscopic textural similarity. Similarly in any one rock a lapillus–sized clast that is distinct from matrix on outcrop due to its size and weathering colour, in thin section may exhibit only minor differences in mineralogy and none in texture. A typical sample, seen in thin section, contains feldspar + quartz (55 percent), amphibole (actinolite or hornblende, 15 percent), biotite (15 percent), carbonate + chlorite (10 percent),

epidote (4 percent), and opaques (1 percent). Grain size ranges from 0.05 mm to 0.5 mm. A parallel orientation of hornblende, biotite, and chlorite defines a foliation.

Tahoe Lake Area. The pyroclastic rocks within a 2–8 km radius of Tahoe Lake, include rocks that differ markedly in fragment size. Maximum fragment size is about 30 cm and fragments are usually ellipsoidal but occasionally blocky. They are similar to the flows around Tahoe Lake in that they are more siliceous than other pyroclastic rocks in the map–area. In outcrop they are light grey coloured and tough. Locally the rocks are intensely sheared due to the presence of several faults in the vicinity of Tahoe Lake.

As seen in thin section, the rocks are foliated and have a fine–grained (0.03 mm) matrix composed of quartz, feldspar, biotite, muscovite, opaques, with or without amphibole or carbonate. Larger fragments range from matrix size to those too large to be seen in a thin section. The most easily discernible fragments are now composed of biotite and are assumed to have originated as mafic fragments or ferromagnesian mineral fragments. Fragments of feldspar crystals are common.

Eastern Margin of the Belt. Within 3–4 km of the eastern contact between the supracrustal rocks and the granitic batholithic rocks, there is a high proportion of intermediate pyroclastic and flow rocks within the supracrustal sequence. The pyroclastic rocks weather grey to grey–green in outcrop, mafic fragments are dark coloured, felsic fragments light coloured. On fresh surfaces the rocks are dark grey. Clasts range in size from about 75 cm to ash size. Most of the clasts are ellipsoidal, but some outcrop areas do contain large fragments that are blocky. The ellipsoidal shape of clasts is considered by the author to be a function of tectonic deformation; none of the rocks described in this report as pyroclastic bear any evidence of sedimentary reworking. The conglomerates that occur in the upper part of the rock sequence in this part of the map–area contain a high proportion of volcanic rock fragments. They are distinguished from the pyroclastic rocks by their poly–lithic character; in particular the presence of granitic fragments is interpreted to indicate a mixed volcanic–plutonic provenance.

In thin section the lithic fragments (from about 0.05 mm or more in diameter) are set in a fine grained groundmass (crystals about 0.02 mm in diameter) composed essentially of feldspar, quartz, hornblende, opaques, with or without minor biotite and carbonate. In any particular rock, most of the clasts closely approximate the matrix in composition and are flattened wispy fragments that presumably were originally pumiceous and then recrystallized. They now have the same mineralogy and texture as the matrix. Fragments more felsic or mafic than the matrix are most easily recognized. The more felsic fragments are usually quartz–rich and ferromagnesian–poor. The more mafic fragments, although their outlines may have been destroyed, are usually preserved as clumps of biotite and opaques or clumps of amphibole and opaques. The pyroclastic rocks adjacent to the granitic contact, for example 3–4 km south of Shrimp Lake generally have hornblende rather than biotite as a ferromagnesian mineral, and contain oligoclase rather than albite–oligoclase.

Some 200 m north of the most northerly part of Shrimp Lake there is an outcrop of sheared and brecciated rock that was considered during field mapping to be either intermediate tuff or sedimentary rock. It has a light green to brown weathered surface and a dark grey fresh surface characterized by many prismatic crystals. On outcrop this rock type appears to grade to the west into intermediate pyroclastic rocks without any prismatic crystals. The development of the acicular

crystals (amphiboles) may have been a result of alteration perhaps related to the adjacent subvolcanic intrusion. In thin section the rock is composed primarily of randomly oriented porphyroblastic actinolite up to 2 mm long set in a very fine matrix (crystals about 0.02 mm in diameter) of feldspar. Quartz may also be present, but identification at this scale was not possible; a few crystals of biotite were observed as well as sphene. The exact origin of this rock is unclear, but the original field concept is worthy of consideration.

Crystal Tuff near Mattson Lake. Most of the crystal tuffs in the map–area occur east and southeast of Mattson Lake; the remainder occur southeast of Nipa Lake and west of Atikamik Lake. The striking characteristic of the rock on outcrop is the abundance of grey to white feldspar crystals (Photo 1). The rock has an overall grey colour with white feldspar crystals in positive relief on the outcrop surface, and where present, dark mafic fragments in negative relief. The lithic fragments are generally ash size but in some outcrops many reach lapillus size (Photo 2).

Most of the feldspar crystals are euhedral and intact. However, many have corners broken off. Since there was no outward evidence to suggest that the physical degradation was due to tectonic stress, and no evidence of impact shattering of the crystals, it is assumed that crystal breakage occurred before deposition unless the rock is an ash flow in which case broken crystals would be expected (Yamada 1973). The feldspar crystals show no strain effects due to post–depositional deformation, whereas in the same rock mafic fragments are foliated and ellipsoidal in shape.

Distinct bedding was not observed in outcrop. Subtle variations in feldspar grain size and density were observed, and these may be an expression of bedding.

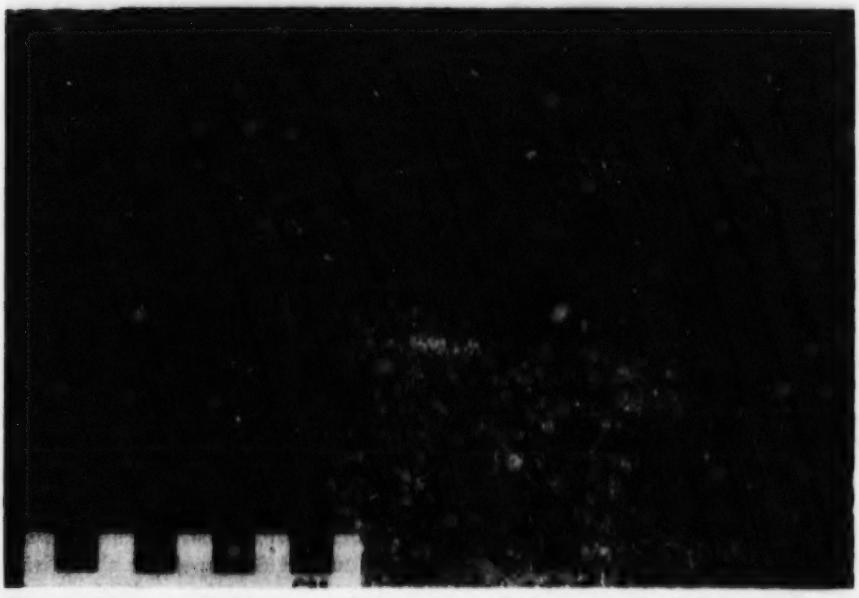

Photo 1. ***Crystal tuff, from east of Mattson Lake. Feldspar crystals stand out on the outcrop surface. Dark blotches are mafic fragments. Subdivisions on the scale card are 1 cm long.***

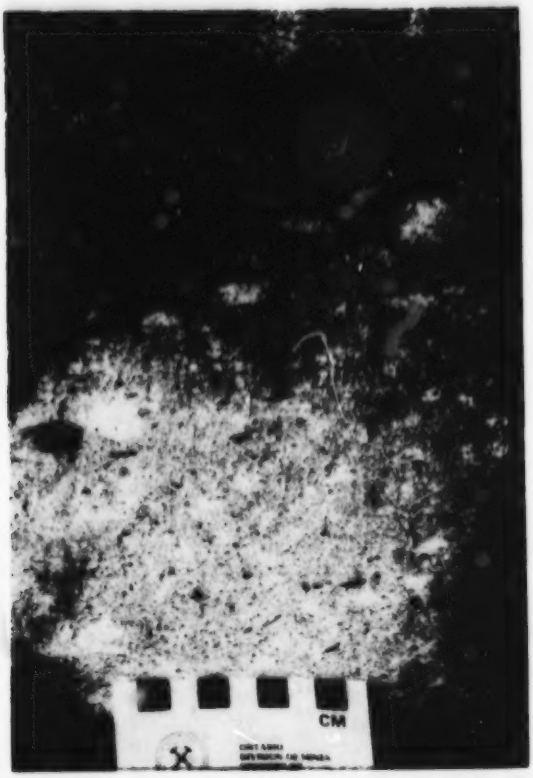

Photo 2. *Crystal and lithic tuff from the west shore of Mattson Lake. Dark areas are mafic fragments.*

Alternatively the lack of obvious beds may be a result of the small size of most outcrops.

In thin section, the feldspar crystals appear as "phenocrysts" in a very fine grained (about 0.01 mm) matrix. Maximum grain size of the feldspar crystals is about 1 cm, most range from 0.5 mm to 3.0 mm. Elliptical clots of biotite and hornblende about the same size as the feldspar crystals are interpreted to be recrystallized mafic fragments. Fragments up to several millimetres long and similar in composition and grain size to the matrix are common. The proportions of fragments to matrix range from about 4:1 to about 1:4. Quartz is present in some localities as fragments, the quartz grains often show evidence of shattering in contrast to the feldspars. The composition of the matrix is not known because of the fine grain size. In general the rocks have not been subjected to high grade metamorphism. Twinned plagioclase crystals range in composition from An_0 to An_{44}.

A noteworthy textural feature seen in thin section is the indistinct edges of plagioclase crystals. This is thought to be due to thermal effects during deposition of the rock. Such textures were not observed in feldspars in nearby metasediments suggesting that this feature is not metamorphic.

Chemistry of Metavolcanics

Two traverses were made southeast of Shrimp Lake across the strike of the intermediate and mafic metavolcanics to obtain samples of the metavolcanics for

TABLE 2. CHEMICAL ANALYSES OF VOLCANIC ROCKS FROM SOUTH AND SOUTHEAST OF SHRIMP LAKE.

Major Elements	weight percent						
	1	2	3	4	5	6	7
SiO_2	57.7	64.0	66.5	64.9	63.1	62.2	64.8
Al_2O_3	16.6	15.4	15.6	16.6	15.0	15.3	16.0
Fe_2O_3	0.87	0.50	0.24	0.27	0.56	0.24	0.37
FeO	4.30	3.33	2.67	2.74	3.93	3.63	2.74
MgO	4.18	3.62	2.70	2.77	4.35	3.96	3.15
CaO	6.82	4.79	4.23	3.78	5.48	6.40	4.65
Na_2O	4.08	3.73	3.71	4.10	3.77	3.90	3.76
K_2O	2.29	2.55	2.52	2.88	2.01	2.33	2.58
TiO_2	0.60	0.34	0.29	0.32	0.33	0.34	0.34
P_2O_5	0.13	0.14	0.14	0.15	0.12	0.12	0.13
S	0.31	0.02	0.04	<0.01	0.06	<0.01	<0.02
MnO	0.14	0.09	0.06	0.05	0.10	0.12	0.06
CO_2	0.22	0.20	0.16	0.20	0.18	0.15	0.22
H_2O+	0.16	0.51	0.09	0.30	0.24	0.21	0.17
H_2O-	0.25	0.28	0.31	0.27	0.24	0.23	0.22
TOTAL	98.6	99.5	99.3	99.3	99.5	99.1	99.2
S.G.	2.77	2.71	2.70	2.70	2.75	2.75	2.73

Trace Elements	ppm						
Ba	400	390	330	620	690	620	650
Co	25	15	10	10	15	15	20
Cr	255	190	145	165	230	180	200
Cu	45	10	25	5	30	<5	10
Li	40	20	60	45	30	6	15
Ni	110	60	40	45	65	55	60
Pb	20	20	10	15	20	20	30
Zn	70	75	50	60	85	75	65

CONTINUED

Note: Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto. For sample locations, see Map 2497, back pocket.

chemical analyses. The location of the traverses and the sample localities are marked on the map.

The analyses are presented in Table 2. The analytical data have been plotted on a AFTM cation diagram (Jensen 1976) in Figure 2. The analyses plot in two distinct groups. Those rocks described as intermediate in the field form a cluster in the calc–alkalic andesite and dacite classes whereas those described as "mafic" are spread over several classes including magnesian tholeiitic basalt, iron–rich tholeiitic basalt, tholeiitic andesite and tholeiitic dacite. There are three possible explanations for the bimodal distribution of compositions.

1. The intermediate rocks may have been sampled at a low angle to the strike (bedding or flow strike direction as distinct from foliation direction is not easily determined in this part of the map–area), and thus the potential range of compositions was not completely sampled.

2. The mafic rocks have been subjected to more intense alteration than the intermediate rocks.

3. The area sampled represents bi–modal volcanism.

TABLE 2. CONTINUED.

Major Elements	weight percent						
	8	9	10	11	12	13	14
SiO_2	65.9	63.5	63.2	62.8	59.8	61.1	67.9
Al_2O_3	16.5	16.2	16.1	16.2	18.1	16.5	13.8
Fe_2O_3	0.25	0.50	0.56	0.51	0.66	0.29	0.56
FeO	2.52	3.11	3.04	3.11	3.48	3.41	2.52
MgO	2.37	3.09	3.10	3.44	3.70	3.99	3.27
CaO	3.59	5.17	5.16	5.06	3.97	5.24	6.34
Na_2O	4.39	4.71	4.55	4.39	4.84	4.02	3.15
K_2O	2.40	1.45	1.44	2.00	2.96	3.58	0.77
TiO_2	0.31	0.34	0.33	0.34	0.36	0.31	0.36
P_2O_5	0.13	0.14	0.15	0.13	0.15	0.12	0.12
S	0.03	0.02	0.02	<0.01	0.02	<0.01	<0.01
MnO	0.05	0.08	0.08	0.07	0.07	0.10	0.09
CO_2	0.17	0.14	0.13	0.20	0.11	0.27	0.14
H_2O+	0.11	0.32	0.29	0.62	0.56	0.57	0.13
H_2O-	0.25	0.27	0.24	0.22	0.25	0.24	0.24
TOTAL	99.0	99.0	98.4	99.1	99.0	99.7	99.4
S.G.	2.69	2.72	2.72	2.73	2.73	2.69	2.74

Trace Elements	ppm						
Ba	460	350	300	560	570	780	460
Co	15	15	10	10	20	10	10
Cr	130	175	170	175	230	150	190
Cu	15	20	20	10	15	5	10
Li	20	35	30	85	155	15	25
Ni	40	40	40	55	65	30	40
Pb	15	25	25	20	20	30	35
Zn	55	70	70	75	80	80	70

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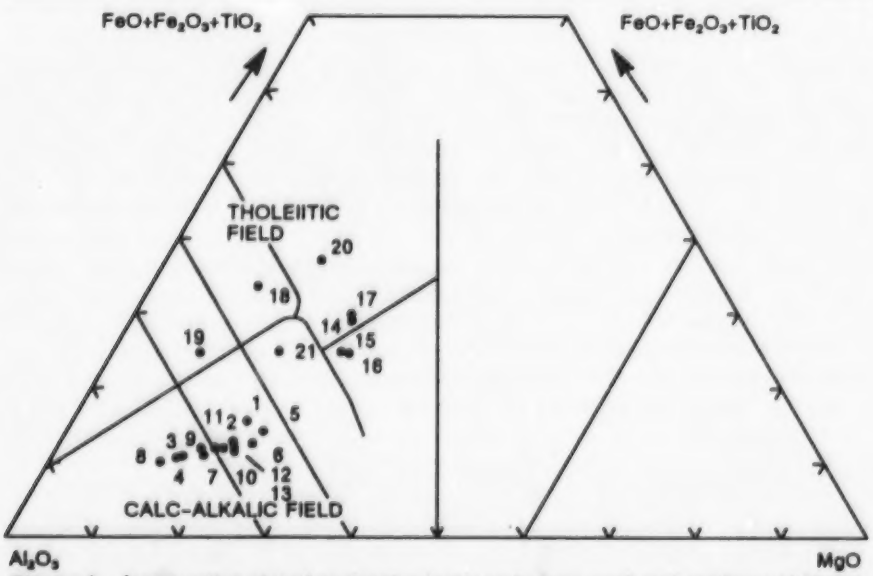

Figure 2. *Jensen cation plot of analyzed volcanic rocks from south and southeast of Shrimp Lake. Analyses are given in Table 2; locations are shown on map in back pocket.*

TABLE 2. CONTINUED.

Major Elements	weight percent							
	15	16	17	18	19	20	21	22
SiO_2	50.2	48.8	48.8	48.6	45.5	53.8	46.9	50.3
Al_2O_3	14.6	16.3	16.1	14.2	17.1	16.8	12.0	16.4
Fe_2O_3	1.60	1.20	0.90	0.40	0.70	0.73	2.00	1.06
FeO	10.5	9.41	9.63	11.5	12.5	6.97	10.9	8.23
MgO	6.47	6.87	7.24	6.42	3.38	2.17	3.91	4.65
CaO	11.8	10.7	11.5	12.8	14.2	12.9	19.3	12.6
Na_2O	1.14	3.18	2.60	2.02	1.71	2.73	0.61	3.13
K_2O	0.32	0.44	0.34	0.28	0.56	0.22	0.09	0.27
TiO_2	0.98	1.03	1.03	1.06	1.44	1.46	0.96	1.16
P_2O_5	0.11	0.09	0.09	0.10	0.15	0.14	0.09	0.12
S	0.01	0.01	0.01	0.0	0.07	<0.01	0.16	0.17
MnO	0.23	0.25	0.22	0.33	0.46	0.32	0.25	0.30
CO_2	0.16	0.22	0.13	0.13	0.20	0.12	0.23	0.22
H_2O+	0.68	0.62	0.49	0.43	0.43	0.40	0.66	0.58
H_2O-	0.22	0.21	0.23	0.22	0.26	0.24	0.30	0.26
TOTAL	99.0	99.3	99.3	98.5	98.7	99.0	98.4	99.4
S.G.	2.91	2.97	3.00	3.03	3.08	2.94	3.19	2.95
Trace Elements				ppm				
Ba	60	100	40	80	60	60	50	60
Co	45	45	45	50	45	40	50	25
Cr	275	305	300	275	320	305	225	290
Cu	45	40	50	<5	25	15	65	80
Li	20	35	20	10	70	30	20	20
Ni	105	125	125	105	90	95	65	45
Pb	10	<10	<10	15	10	15	10	<10
Zn	115	110	95	130	120	70	140	105

In order to assess these viewpoints the analyses were processed to check for alteration by G. Soucie (Geoscience Laboratories, Ontario Geological Survey) using the method outlined by Beswick and Soucie (1978). This indicated that the mafic metavolcanics had been more intensely and variably altered than the intermediate rocks, hence the scatter on the AFTM diagram. The initial composition of the mafic rocks is not known. This dark green to green–black colouration and presence of pillows, and lack of feldspar phenocrysts would suggest that they are tholeiitic basalt.

In petrographic descriptions of intermediate metavolcanics and of metasediments from north of Shrimp Lake, mention is made of actinolite–bearing metavolcanics and of garnet–cordierite–anthophylite bearing metasediments. An analysis by the Geoscience Laboratories, Ontario Geological Survey, of such amphibolitic rock is given in Table 3, column A. The data plots on the AFTM diagram as shown in Figure 3, position A. The rock is a dark greenish grey and in the field was classed as an intermediate metavolcanic the same as intermediate rocks from south of Shrimp Lake that are plotted in Figure 2. If the rock is an intermediate metavolcanic it has been considerably enriched in Fe compared to the other intermediate rocks. Arguably it may be of metasedimentary origin.

The rocks north of Shrimp Lake, on either side of the fault near the eastern end of the Lake, are severely brecciated and sheared. The dominant lithologies are shown on the map; however there are many rock types including ultramafic

TABLE 3. CHEMICAL ANALYSES OF SELECTED VOLCANIC ROCKS.

Major Elements			weight percent			
	A	B	C	D	E	F
SiO_2	56.0	53.4	57.0	55.7	61.7	67.1
Al_2O_3	16.7	14.1	15.6	13.7	19.0	15.8
Fe_2O_3	1.90	0.28	1.46	1.78	1.72	0.87
FeO	10.3	6.22	7.11	4.59	6.30	2.74
MgO	4.37	11.4	4.47	8.42	3.03	1.61
CaO	2.88	10.6	5.00	7.42	0.89	3.37
Na_2O	0.99	1.04	1.67	3.27	0.44	3.08
K_2O	2.22	0.15	3.15	1.68	2.80	1.88
TiO_2	0.94	0.66	0.69	0.44	0.75	0.49
P_2O_5	0.12	0.28	0.26	0.17	0.23	0.14
S	0.18	0.03	0.03	<.01	0.03	0.12
MnO	0.21	0.18	0.15	0.14	0.10	0.04
CO_2	0.22	0.35	0.58	0.21	0.22	0.35
H_2O+	2.49	0.34	0.91	0.81	0.90	0.81
H_2O-	0.37	0.23	0.43	0.31	0.29	0.22
TOTAL	99.9	99.3	98.5	98.6	98.4	98.6
S.G.	2.86	2.93	2.81	2.83	2.81	2.66
Trace Elements			**ppm**			
Ba	200	80	290	460	580	420
Co	30	50	20	30	15	15
Cr	720	1100	120	760	180	90
Cu	45	30	25	20	10	15
Ni	120	385	25	185	20	30
Pb	20	15	15	20	20	25
Zn	145	90	110	105	95	60

Notes: Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto. Samples/Field Numbers: A: G-75-115; B: G-75-148; C: G-75-62; D: G-75-59; E: G-75-85; F: G75-129. For locations, see text.

rock and black carbonate rock present in this area. A sheared rock, considered in the field to be an intermediate crystal tuff with mafic clots because of its texture and medium to dark grey colour, on analysis yielded the composition shown in Table 3, column B. Plotted on an AFTM diagram, Figure 3, point B, the rock falls in the field of basaltic komatiite, gradational to magnesian tholeiitic basalt. A similar rock from the knob–like headland on the eastern side of MacDowell Lake about 2 km from Mattson Lake has a composition as shown in Table 3, column D. Plotted on an AFTM diagram (Figure 3, point D) the composition is magnesian tholeiitic basalt. The field identification of these two sheared rocks as intermediate rather than magnesian may indicate that (a) these magnesian rocks are more abundant than shown on the maps, (b) the shearing in the analyzed rocks emphasizes the occurrence of the magnesian rocks and at the same time masks their character. Whether the magnesian character of the rocks is original or secondary is not known.

A sample of medium to dark grey tuff from an outcrop west of the stream flowing from Mattson Lake into MacDowell Lake has the composition shown in Table 3, column C. It plots on an AFTM diagram in the field of calc–alkalic basalt (Figure 3, point C). A sample of intermediate pyroclastic rock from 2.5 km east of Tahoe Lake, and a similar rock from 1.6 km south of Tahoe Lake on analysis have compositions as shown in Table 3, column E and F respectively. On

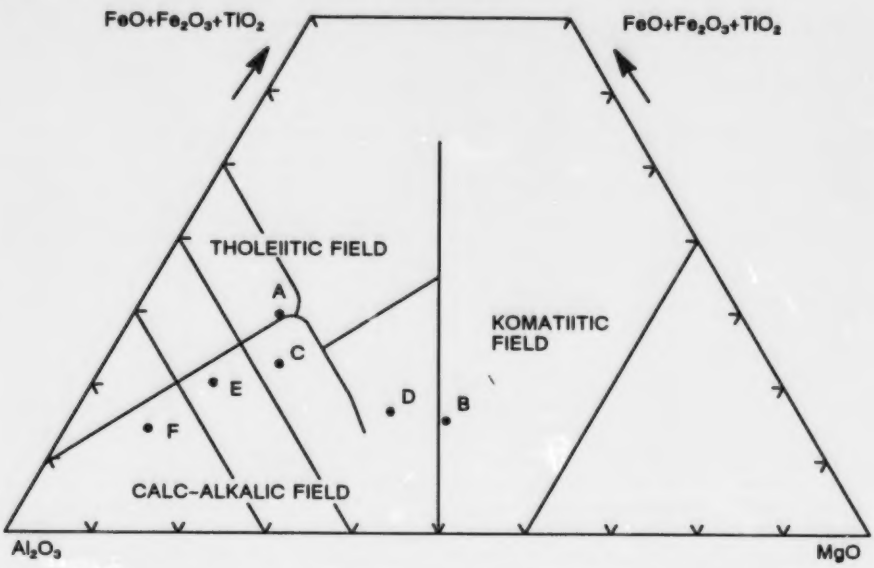

Figure 3. *Jensen cation plot of analyzed volcanic rocks from a number of localities within the map-area. Analyses are given in Table 3.*

an AFTM plot the rock from east of Tahoe Lake plots in position E in the calc–alkalic andesite field and the rock from south of Tahoe Lake plots in position F, in the calc–alkalic dacite field. This dacitic composition compares with the most felsic of the intermediate rocks from south of Shrimp Lake (*see* Figure 2).

METASEDIMENTS

Metasediments are not common within the map–area. This is in contrast to adjacent areas to the north (*see* Wood 1980). Both clastic and chemical metasediments are present. The clastic metasediments are found close to the eastern and western boundaries of the belt, and east and west of Tahoe Lake. The chemical metasediments are found close to the eastern and western belt boundaries, southeast of Nipa Lake, just to the east of Tahoe Lake, and in the southeastern part of the map–area.

Clastic Metasediments

The clastic metasediments have been classified as conglomerate, sandstone or mudstone based on particle grain size. A mudstone is a rock in which particles less than 0.06 mm in diameter constitute more than 75 percent of the rock by volume. A sandstone is a rock composed of particles between 0.06 mm and 2 mm in diameter; it may contain up to 15 percent silt or clay sized particles, or up to 15 percent granule size or larger clasts. A conglomerate is a rock containing more than 15 percent by volume of granule size or larger clasts.

The general distribution of clastic metasediments is outlined above. On a more detailed scale, there are three noteworthy aspects. Firstly, conglomeratic rocks are restricted to localities close to the eastern and southeastern boundary of the belt; sandstones occur preferentially near the eastern boundary and in the central parts of the greenstone belt; and mudstones are most abundant near the

western boundary of the belt. There is commonly an association between the mudstones and chemical metasediments. Secondly, metamorphic grade is higher in those parts of the map–area near the eastern and southeastern contact with the granitic rocks. Metamorphic index minerals (garnet and andalusite) are present in thin sections of metasediments about 2 km southeast of Tahoe Lake. Thirdly, the metasediments within 1 km east of, 2 km south of, and 2 km west of Tahoe Lake are all muscovite–bearing. This is in sharp contrast with most of the metasediments in other parts of the map–area which do not contain muscovite or other potassic minerals.

Conglomerate (Polymictic)

Conglomerate with Arenaceous Matrix. Conglomerate types with arenaceous matrix include boulder to cobble and pebble to granule orthoconglomerate, and boulder to pebble paraconglomerate. These rocks are found principally to the west and southwest of Atikamik Lake where there are no large outcrops of conglomerate. The two rock types may occur together or separately and in many localities they are interbedded with sandstone and mudstone.

The two conglomerate types can be readily distinguished in the field. The orthoconglomerate is by definition clast–supported, and within the map–area, most of the clasts are rounded. In contrast the paraconglomerate is by definition matrix–supported, and within the map–area most of the clasts are angular. Most of the clasts are of cobble or pebble size, however, the orthoconglomerate may contain boulders up to 30 cm in diameter. The clasts are always stretched parallel to the regional foliation. Beds are seldom more than 2 m thick, and may be normally graded. Orthoconglomerate beds are generally relatively thick, whereas paraconglomerate beds are relatively thin.

The most abundant clast type is felsic to intermediate metavolcanics, however, clasts of mafic metavolcanics, chert, and granitic rocks are not uncommon. In some outcrop areas the heterogeneity of clast compositions was used to distinguish metasediments from pyroclastic rocks.

The weathering colour of a conglomerate bed is dependent on its constituent clasts, thus there is no general weathering colour. Some beds are grey, some buff coloured, some mid–brown and in instances where there are many mafic clasts, or the matrix contains ferromagnesian minerals, the rock may be green coloured.

A typical thin section of a conglomerate matrix shows the rock to be fine grained, with grains 0.05 mm to 5 mm in diameter. Quartz and feldspar are the main components and together constitute up to 80 percent of the rock. Without staining it is difficult to distinguish quartz from feldspar in the finer grain sizes. Biotite, or biotite and hornblende, may constitute up to 15 percent of the rock with opaques and minerals such as cordierite and andalusite constituting the rest of the rock. The feldspar is almost always sodic plagioclase up to An_{20}, however, microcline was observed in some thin sections.

Orthoconglomerate with Sulphide–Rich Arenaceous Matrix (Lahar?). This rock unit can be traced from an outcrop a few hundred metres southeast of the small lake west of Atikamik Lake through a series of outcrops east, northeast, and south of Shrimp Lake, almost to MacDowell Lake. West of Atikamik Lake the unit is underlain by granule to pebble paraconglomerate and overlain by bedded pebble paraconglomerate and cobble orthoconglomerate. Northeast and immediately south of Shrimp Lake it is underlain by deepwater sandstones and overlain by intermediate to felsic metavolcanics. There is a scarcity of outcrop in the most southerly extension of this unit; it is interpreted to lie above mafic flow rocks and

below felsic to intermediate metavolcanics. In the field, this rock type shows considerable variation in texture and composition along strike; it should therefore be stressed that the name given above is a general one and reflects the overall characteristics of what is in essence a stratigraphic unit. With the exception of a few outcrops where clasts of "quartzite" constitute the important framework constituent and one outcrop west of Atikamik Lake where mafic fragments are the dominant clast–type, intermediate to felsic metavolcanic clasts are the most important lithologic type. Some clasts in the field appear to be ultramafic in composition. Most if not all of the clasts are of supracrustal rocks. There are two characteristics of this unit that are unique and make it virtually unmistakeable in the field; these features may or may not be present together. The first feature is the presence of sulphides, principally pyrrhotite and pyrite although some very small specks of chalcopyrite were observed. The sulphides occur not only disseminated in the matrix and within clasts, but also as pebble sized sulphide clasts. The sulphides on weathering give the rock a yellow brown colour, and also where present as a significant rock component (i.e. up to several percent of the rock), cause the rock outcrops to be very friable. The other characteristic feature of the rock is the abundance of "quartzite" clasts, some of boulder size. Each quartzite clast consists of crystal quartz grains of sand or granule size. These clasts are exceedingly tough. Some outcrops are composed solely of cobble–sized fragments of this "quartzite". There would appear to be two possible modes of origin for the quartz rock: it could be recrystallized chert, or recrystallized quartz arenite. Neither mode of origin is particularly satisfactory. Some of the clasts show well defined dark fine–grained layers reminiscent of the bedding seen in cherty rocks. Despite this "bedding" the size of the quartz grains far exceeds that of high grade meta–cherts seen in the map–area and adjacent areas. That the quartzite is recrystallized quartz arenite is a possibility. This would require a source for such a rock within the sedimentological system that gave rise to the conglomerates. There is no obvious source within the map–area, however, this does not preclude that a suitable source did initially exist. It would have consisted of supermature quartz arenite formed from a granitic parent. Clasts of granitic rock in the conglomerates (*see* Wood 1977) would indicate that a suitable granitic progenitor for such a quartzite did exist.

Six thin sections from separate outcrops along the length of this unit indicate that the outcrop diversity is reflected in thin section.

Almost all grain sizes, because of metamorphic recrystallization, exceed 0.05 mm. Individual rock fragments can generally be observed in thin section. The following mineral assemblages are from three different rocks: (1) plagioclase (oligoclase) 40 percent, hornblende 30 percent, quartz 25 percent, biotite 2 percent, opaques 3 percent; (2) hornblende 35 percent, plagioclase 25 percent, quartz 23 percent, sulphides 6 percent, sphene 5 percent, cordierite 3 percent, iron oxides 1 percent, epidote 1 percent, chlorite 1 percent; (3) plagioclase 45 percent, clinopyroxene 20 percent, epidote 19 percent, garnet 10 percent, sulphides and iron oxide 4 percent, quartz 1 percent, hornblende 1 percent. These assemblages demonstrate the diversity in composition of this rock unit.

It should be noted that this unit is intruded by a subvolcanic intermediate stock near Shrimp Lake. The amount of sulphides is greatest in the vicinity of the stock, however, the conglomerate unit is still sulphide–rich away from the stock. This together with the presence of sulphide clasts would suggest that although the subvolcanic intrusion may have introduced some sulphides, it acted primarily as a mechanism for concentrating sulphides already in the country rocks.

The conglomerates in the MacDowell Lake area are the equivalents of conglomerates in the Hewitt Lake area immediately to the north, and as such, were deposited in a submarine fan system. The sulphide–rich conglomerate differs from the other conglomerates in the MacDowell Lake area as follows: it extends further south than the other conglomeratic rocks; it contains sulphide clasts and quartzite clasts; most if not all of the clasts are of supracrustal rock; and throughout its strike length the unit shows no internal organization. The submarine pillowed mafic flows and graded sandstones that underlie the sulphide–bearing conglomerate imply that it also is a submarine deposit. The character of this unit together with its deep–water depositional environment suggest a debris–flow origin, but with a source different from that of the other conglomerates west of Atikamik Lake or in the Hewitt Lake area (Wood 1980). If this sulphide–bearing conglomerate had been derived from a different submarine fan system than the one which supplied the detritus in the area near Atikamik Lake and in the Hewitt Lake area, more sediment of this type would be expected from the fan system. This is not the case, and the sulphide–bearing conglomerate assumes a unique status. Because of the dominance of intermediate volcanic clasts in the rock framework, a volcanic source is indicated. This, combined with the unsorted texture of the rock, suggests that it may have originated by slumping off the side of a volcano. Although it has been argued above that this sediment was deposited in deep water, the volcano from which the sediment was derived may have been submarine, or it may have been subaerial. Technically, the sediment could be called a 'lahar' (Mullineaux and Crandell 1962).

Sandstone and Mudstone

The sandstones and mudstones within the map–area are discussed together because (a) they are not abundant, (b) they are associated together in the field, and (c) in the eastern part of the map–area metamorphism has been sufficiently intense that all of the metasediments have been thoroughly recrystallized such that there is little mud–sized material in the rocks. The mudstone term is therefore used for rocks with a high phyllosilicate mineral content. There is a natural areal subdivision based partly on grain size and partly on metamorphism of these rocks within the map–area. The first area lies north of MacDowell Lake, west of Mattson Lake and west of the fault just to the east of Tahoe Lake; the second area is the remainder of the metavolcanic–metasedimentary belt.

Area No. 1. The metasediments in this area are predominantly fine grained (see accompanying map, back pocket). The metamorphic grade of the rocks is low so that although recrystallized, metamorphic minerals indicative of high rank metamorphism have not developed nor has there been extensive coarsening of grain size, in contrast to rocks from Area 2.

With the exception of a mafic mudstone described below, on outcrop the rocks weather to a light brown, grey–brown, or in some of the thinly laminated siltstones, a buff colour. Bed thickness is less than 30 cm in the sandstones and less than 2 cm in the siltstones. This thin bedding is a feature associated with the fine grain sizes typical of this part of the map–area. No sedimentary structures other than bedding were observed in rocks in this part of the map–area.

A sandstone herein classified as lithic arkose was collected from an outcrop about 2 km southeast of Nipa Lake. It has a light grey fresh surface, and in thin section its intact framework is apparent. Matrix content is less than 15 percent. The rock is very murky looking as a consequence of low grade metamorphism of feldspar (plagioclase) and felsic rock fragments. The plagioclase is altered to albite, epidote, calcite and sericite. Quartz occurs as single crystals or polygonal

aggregates, which reach 1.7 mm in length. Individual grains in the polygonal aggregates are about 0.02–0.03 mm in diameter and the aggregates are interpreted to be recrystallized chert. Most of the quartz, feldspar, and rock fragments are about 0.6 mm in diameter. Approximate clastic proportions are feldspar 46 percent, quartz 22 percent, rock fragments 11 percent, biotite + chlorite 8 percent, epidote 5 percent, muscovite 3 percent, carbonate 2 percent, opaques 2 percent, and zircon + accessories 1 percent.

Two thin–sectioned rock samples from the areas of fine–grained metasediments west and south of Tahoe Lake show the grain–size to be from 0.04 mm to submicroscopic. In one sample there are flattened sand–sized grains similar to the matrix. Mineralogy is quartz + feldspar 65–70 percent, biotite 15 percent, muscovite 0–15 percent, chlorite up to 7 percent, opaques 2 percent, and epidote 3 percent. Beds are about 2 mm thick, some show grading on a microscopic scale. Metamorphism has been sufficient to recrystallize the rock and impose a foliation, but insufficient to develop large grain size or high rank metamorphic index minerals. Muscovite crystals cut across biotite crystals, and are assumed to have grown after the biotites.

About 1.6 km southeast of Nipa Lake near the contact with the granitic rocks is a finely bedded metasediment with a green–brown weathering colour. This rock–type is localized in occurrence. A thin–section shows that beds are less than 2 mm thick, and the average grain size is about 0.03 mm. The rock has a strong foliation defined by hornblende and biotite. Minerals present are quartz + feldspar 50 percent, hornblende 22 percent, biotite 18 percent, epidote 5 percent, and opaques 5 percent. Compared to the lithic arkose described above which was collected about 0.4 km to the southeast, the metamorphic grade of this mafic mudstone is higher.

Area No. 2. Sandstones are more abundant than mudstones in this area. In thin section most of the minerals in the mudstones are seen to exceed 0.05 mm in grain size, but the mudstones are not coarse grained enough to be confused with the sandstones in the field. The mudstones also contain a much higher proportion of phyllosilicates.The sandstones and mudstones have been subjected to medium grade metamorphism. The rocks are foliated and schistose due to the oriented development of phyllosilicate minerals. Graded bedding is a common feature in these metasediments and metamorphic inverse grading has developed locally. The metamorphic grading is caused by cordierite and andalusite porphyroblasts, up to 2 cm in length, which have grown in the originally fine–grained part of a bed, thus reversing the sense of the original grading. Quartz is present in all of the metasediments, and single crystal grains 2–4 mm in diameter are common especially in the lower parts of graded units.

The size and abundance of metamorphic index minerals decrease in a westerly direction, so that southeast of Tahoe Lake, only garnet was recognized on outcrop. Similarly, in the fault structure south of Mattson Lake and east of MacDowell Lake, metamorphic index minerals are not obvious on outcrop.

The colour of the weathered surface of the arenaceous rocks is grey to grey–brown. The more argillaceous rocks are generally brown colored. The grey colouration is a function of the quartz content, whereas the brown colouration is a function of the content of ferromagnesian phyllosilicates.

Few of the sandstone beds are more than a metre thick. Most are less than 50 cm thick. Those between about 50 cm and 10 cm are classed as medium bedded on the accompanying map, those less than 10 cm are classed as thinly

bedded. There is an overall positive correlation between grain size and bed thickness.

In order to illustrate differences and similarities in mineralogy and texture within this unit, several thin-sectioned rocks from different parts of the map-area are described below. A sample from the south shore of Atikamik Lake weathers buff to grey on outcrop, and is grey on fresh surface. As seen in thin section the rock has a strong foliation defined by biotite crystals. Quartz grains range in size from 0.05 mm to 0.5 mm, porphyroblasts of cordierite reach 2 mm in diameter. Minerals present include quartz and oligoclase 74 percent, cordierite 15 percent, biotite (straw-yellow to brown) 10 percent, and opaques + accessories 1 percent. Minute needles of sillimanite were observed in a few parts of the slide, however, they were not well enough developed to be considered an equilibrium phase.

A sample from an outcrop 2.5 km southeast of Tahoe Lake weathers light grey and on fresh surface is spotted white-grey. Thin section examination shows that grain size of quartz and feldspar ranges from about 0.04 mm to 0.5 mm, and compared to the sample described above, shows less well developed recrystallization phenomena. Poikiloblasts of andalusite up to 3 mm long constitute about 30 percent of the rock, quartz and feldspar 50 percent, biotite 10 percent, garnet 5 percent, opaques 2 percent, chlorite 2 percent, and muscovite 1 percent. The chlorite occurs as an alteration product of biotite.

Sillimanite was recognized in outcrops of metasediments on the south shore of the west end of Armstrong Lake. Cordierite and garnet were also recognized on this outcrop. Cordierite porphyroblasts up to 2 cm long were noted.

A thin-sectioned sample from an outcrop of fine-grained, brown-weathering metasediment on the south shore of Armstrong Lake near the map-area boundary contains almost no sillimanite except for a few clusters of tiny needles sporadically distributed thoughout the slide. Quartz and feldspar between 0.05 mm and 0.30 mm in diameter constitute about 75 percent of the rock, which despite the range in grain size has an equigranular appearance. Cordierite porphyroblasts up to 3 mm long constitute about 5 percent of the rock. Biotite, about 15 percent of the rock, defines the foliation in the rock; however, oriented biotite crystals within the cordierite porphyroblasts are at an angle of about 55 degrees to the main foliation trend, thus suggesting that the cordierite crystals grew after the biotite was formed and subsequently have been rotated. The cordierites have abundant inclusions of opaque minerals as well as some inclusions of quartz and feldspar. Opaque minerals constitute about 4 percent of the rock and chlorite, sillimanite and accessories constitute the remaining 1 percent.

South of Shrimp Lake andalusite porphyroblasts up to 1 mm in length are present in outcrops of brown-weathering metasediments. Thin sections show that the grain size of quartz and feldspar ranges from 0.05 mm to 0.5 mm. Biotite and andalusite occur as poikiloblasts. Biotite seldom occurs as inclusions in andalusite, or vice versa. The andalusite crystals, as well as having inclusions of quartz and feldspar, contain opaques or carbonaceous material in a diamond-shaped pattern. Minerals present in the rock include quartz and feldspar 62 percent, biotite 17 percent, andalusite 15 percent, opaque minerals 3 percent, cordierite 1 percent, chlorite 1 percent, and muscovite 1 percent.

The cordierite crystals are poorly formed. Muscovite laths overgrow other minerals and occur in a random orientation suggesting that they are the youngest mineral in the rock and are post-tectonic and post-kinematic.

There are several outcrops of sandstone and mudstone in the fault graben east of MacDowell Lake and south of Mattson Lake. These rocks are strongly

foliated in outcrop. On an island near the "V" in MacDowell Lake, thinly bedded clastic metasediments interbedded with chemical metasediments have been severely deformed. Thin sections of the clastic rocks show that they are of lower metamorphic rank than rocks in Area No. 1 described above. Grain size ranges from 0.02 mm to 1 mm with the average being about 0.1 mm. Minerals present include quartz + plagioclase 75 percent, biotite 12 percent, chlorite 8 percent, epidote 3 percent, and opaques + accessories 2 percent. The biotite and chlorite define the foliation in the rock, however, quartz and feldspar have been stretched in the foliation plane, thus accentuating the phyllosilicate–defined foliation. The rocks are fractured and veined by quartz and in some places by pegmatitic quartzofeldspathic veinlets. Chlorite has formed from biotite. The mineral alteration, veining, and quartz and feldspar flattening are considered to be the result of the deformation that has affected rocks in this part of the map–area.

In the section on intermediate to felsic metavolcanics, mention was made of an amphibolitic metavolcanic near Shrimp Lake. In the same vicinity just north of Shrimp Lake there are amphibole–bearing metasediments which during field mapping were thought to be sillimanite–bearing. In hand specimen the mineral in question occurs in felted clumps or single colourless acicular crystals. On outcrop the rock weathers to a dark brown colour, and is light brown on fresh surface. In thin section the rock has an indistinct foliation defined by amphibole crystals which are generally acicular and up to 2 mm long. In thin section the amphibole is very pale green to colourless, has oblique extinction and is twinned. By optical means, it was determined to be cummingtonite. In two samples from different outcrops the amphibole shows slight differences in optic axial angle. Cummingtonite constitutes 23 percent of the rock. Other minerals present are quartz 35 percent, cordierite 25 percent, garnet 10 percent, biotite 5 percent, and opaques 2 percent. The garnets are euhedral and undeformed, the cordierites are poikiloblastic. The thin sections were not stained for plagioclase, however, some 35 optical determinations on potential plagioclase in each thin section revealed that all of the crystals were quartz. This is the only thin–sectioned sample of clastic metasediments from the map–area that does not contain plagioclase. The absence of feldspar and the presence of cummingtonite and cordierite which contain no calcium or sodium, leaves only biotite as an alkali–bearing mineral, and no calcium–bearing mineral. Compared to other metasedimentary rock–types the rock is deficient in alkalis and calcium but high in magnesium, thereby suggesting that the rock may have been altered prior to or during the early stages of metamorphism.

Chemical Metasediments

Chemical metasediments are not abundant within the map–area. Their areal distribution has been outlined in the introductory section on metasediments.

Although five different rock types are distinguished on the map, there is an apparently complete spectrum between the various rock types, all of which contain metamorphosed chert as the fundamental component. In outcrops designated as chert on the accompanying map, the rock is typified by a layered appearance, layers ranging in width from about 1 mm up to several centimetres. The layers represent individual beds of metamorphosed chert. The other rock types are all interlayered with chert.

On weathered surface the chert is grey or grey–black, the sulphide ironstone yellow–brown. The para–amphibolite is green, and the magnetite ironstone is black. Thin–sectioned samples of chert indicate that the rock consists of inter-

locking quartz grains between 0.05 mm and 0.5 mm in diameter. Despite the range in grain size the rock has an equigranular appearance. Impurities of amphibole, biotite, magnetite, or sulphides are present in the siliceous beds. Ferruginous chert contains between about 5 percent and about 20 percent magnetite. The magnetite ironstone consists primarily of magnetite, with minor quartz. Similarly the sulphide ironstone contains primarily pyrite or pyrrhotite and minor quartz. All of the rock types including the para–amphibolite discussed below contain one or more of pyrite, pyrrhotite, magnetite and amphibole as accessory minerals.

The para–amphibolite sample that was thin–sectioned came from an outcrop west of Mattson Lake, near the granitic contact. It consists of layers of quartz + actinolite and actinolite + magnetite. The quartz averages about 0.15 mm in diameter, and the actinolite is about 0.4 mm in length. The actinolites in the quartz + actinolite layers are parallel, thereby defining a schistosity, and have thin polysynthetic twinning with 001 as twin plane. This twinning in which the twins are at a large angle to the length of a crystal is infrequently observed in rocks within the North Spirit Lake –MacDowell Lake supracrustal belt. The actinolite is pale green and slightly pleochroic; the pleochroism and colour intensity are stronger in the magnetite–rich layers.

Some occurrences, southeast of Nipa Lake, of amphibolitic rock thought to be para–amphibolite were determined by thin–section examination to be immature hornblende–bearing clastic metasediments (*see* Satterly 1941).

METAMORPHOSED MAFIC INTRUSIVE ROCKS

The only metamorphosed mafic intrusive rocks in the map–area occur close to the eastern contact of the supracrustal rocks with the granitic batholithic rocks.

Within the map–area they occur in close spatial association with mafic metavolcanics; in the adjacent map–area to the north (Wood 1980) correlative rocks occur as sills in a predominantly metasedimentary sequence.

The rocks show a range in grain size. Some outcrops contain ferromagnesian phenocrysts up to 2 cm in length (Photo 3), others contain feldspar phenocrysts up to about 1 cm long. The rocks in some outcrop areas consist largely of coarse–grained hornblende and these were considered to have originated as pyroxenites, however thin section study of such rocks indicates that they all contain more than 30 percent feldspar and therefore are gabbroic.

A detailed study of the intrusion along the south shore of Atikamik Lake showed that it is a multiple intrusion consisting of about nine individual intrusions. Each individual intrusion is differentiated and has a mafic, almost ultramafic base and an intermediate top. The more felsic upper part is often fine grained, whereas the rest of the intrusion may be medium or coarse grained. Because of the overlap in grain size and composition between these rocks and the mafic metavolcanics, in some outcrop areas, particularly those east and southeast of Shrimp Lake, distinction between the two is difficult.

In outcrop the rocks are generally medium to coarse grained with a grey, dark greenish grey, or dark green almost black, weathered surface. In some localities, for example near the west end of the south shore of Atikamik Lake, the feldspar crystals have been weathered out and the outcrop surface is rough and pock–marked. In the finer grained rocks a foliation may be apparent, but in the coarser grained rocks a foliation is seldom developed.

A thin–sectioned sample of metagabbro with mafic phenocrysts, from south of Atikamik Lake, shows that in thin section the coarse hornblende crystals (up

to 6 mm long) have a subophitic texture with lath–shaped plagioclase crystals (up to 2.5 mm long). There are also small (less than 0.5 mm) prismatic hornblende crystals and tabular biotite crystals in the rock. The large hornblendes probably represent pyroxene crystals that have been recrystallized, the hornblende having essentially replaced the pyroxene in its original crystal size and shape. Within some of the larger hornblende crystals are small prismatic crystals. Some of the biotite has been replaced by chlorite. Mineral composition is hornblende 47 percent, plagioclase (andesine) 31 percent, biotite 15 percent, chlorite 5 percent, and opaques + sphene 2 percent.

A thin–sectioned sample of medium–grained gabbro shows essentially the same textures except that the maximum grain size is about 1.5 mm. Minerals present include plagioclase (andesine) 50 percent, hornblende 45 percent, opaques 3 percent, clinozoisite 1 percent, and epidote + biotite 1 percent.

A thin–sectioned sample of the felsic portion of a sill from south of Atikamik Lake contains about 76 percent plagioclase (andesine), 20 percent amphibole, 3 percent opaques, and 1 percent epidote. The crystals are not lath–like as in the coarser–grained samples but are equigranular with a grain size between 0.03 mm and 0.4 mm. The plagioclase crystals are marginally larger than the hornblende crystals.

The descriptions above reflect the textures and mineralogy of all thin–sectioned samples. Plagioclase generally is andesine, however some relict feldspars in one thin section are calcic labradorite and are considered to reflect the probable original feldspar composition. It is thought that the hornblende is after pyroxene so that these rocks originally were gabbros rather than diorites as they now are. On this basis they are described as gabbro in the map legend.

Photo 3. ***Coarse–grained ferromagnesian phenocrysts in gabbro from an outcrop near the western end of Atikamik Lake. The phenocrysts are hornblende after pyroxene. The pen top is 3 cm long.***

METAMORPHOSED INTERMEDIATE INTRUSIVE ROCKS

Just to the north and east of Shrimp Lake there is a roughly circular intrusion of metamorphosed intermediate rocks. Host rocks to the intrusion are clastic rocks, specifically the complex sulphide–bearing laharic deposit described under "Metasediments". Except for its western contact, the intrusion has clear–cut contacts with the host rocks. To the north of Shrimp Lake the intrusion contains large inclusions, up to 2 m by 2 m, of ultramafic rock and black carbonate rock. In this area, sulphide mineralization (pyrite and pyrrhotite) has permeated the intrusion as well as the country rock and in a number of outcrops, because of weathering, the contact is indistinct. Other parts of this intrusion are not sulphide–rich, the author therefore considers that the sulphides are not related to the intrusion but to the country rock. The intrusion itself, as a heat source, may have been instrumental in creating the high concentrations of sulphides within the country–rock close to it, and the sulphide–rich part of the intrusion may have originated in a similar fashion.

The rocks of the intrusion appear unaltered in outcrop, but thin section examination shows that they are altered. On outcrop the feldspar phenocrysts which reach about 1 cm in length, are light grey to flesh coloured and stand out against the grey to brownish matrix of the intrusion. Hornblende crystals up to 2 mm in length are also apparent in outcrop.

In thin section the sericitized and epidotized plagioclase phenocrysts (now albite) dominate the rock. The rock has been recrystallized. Hornblende phenocrysts are oriented parallel to the foliation defined by biotite crystals in the matrix. The matrix components of plagioclase, biotite and quartz and hornblende are about 0.03–0.1 mm in diameter.

Approximate mineral amounts are plagioclase 65 percent, quartz 10 percent, hornblende 10 percent, biotite 9 percent, microcline 4 percent, and carbonate + hematite + epidote 2 percent. The rock is considered to have originally been a quartz–biotite diorite.

FELSIC AND INTERMEDIATE INTRUSIVE ROCKS

The felsic and intermediate intrusive rocks are subdivided into post–batholithic intrusive dike rocks, biotitic batholithic intrusive rocks, and hornblendic batholithic intrusive rocks (see Table 1 and Map 2497, back pocket). The latter two subdivisions constitute more than 99 percent of the group, and are areally the most extensive within the map–area.

The post–batholithic intrusive dikes are small, less than 1 m wide east of the major fault zone. It is not known if the dikes cut the supracrustal rocks. There were only a few dikes observed in the granitic terrain. Even if the dikes do occur in the supracrustal rocks, the possibility of observing them would be remote since the outcrop density is low in the map–area and outcrops of supracrustal rocks are small.

The batholithic rocks have been subdivided into two categories based on the presence or absence of hornblende. This does not imply a genetic difference between rocks in the two categories. For example, it is likely that some of the biotitic rocks are the more felsic differentiates of the biotite–hornblende rocks. In the same manner a garnet–muscovite quartz monzonite may well have had a different genesis from a biotite quartz monzonite, nevertheless they are in the same subdivision in the legend.

The distribution of different rock–types (see the accompanying map) is noteworthy in that east of the major fault zone and north of the northeastern arm of

MacDowell Lake there are no hornblendic granitic rocks and many of the outcrops are of leucocratic granitic rock. In this part of the map–area there are seldom more than two granitic phases in any one outcrop. East of the fault zone and south of the northeast arm of MacDowell Lake, hornblendic rocks are present and occasionally three or more phases may be observed on one outcrop.

West of the major fault zone, the average number of phases in any one outcrop is three. Immediately to the south of Nipa Lake one phase per outcrop is not uncommon, however west of MacDowell Lake, particularly in well washed shoreline exposures, there are commonly five or six rock–types of which usually only one is non–batholithic in origin.

Hornblendic Batholithic Intrusive Rocks

The spatial distribution of these rock–types within the map–area is outlined above. The pegmatitic and aplitic rocks which are leucocratic and essentially quartzofeldspathic occur as dikes in the batholithic granitic rocks. The other rock types in this subdivision range in composition from trondhjemite to quartz monzonite; this contrasts with hornblendic granitic rocks in the adjacent area to the north (Wood 1980) which are either trondhjemitic or granodioritic.

A field classification into biotite–hornblende or hornblende–biotite varieties (the more abundant mineral comes second) was attempted but is subject to error given the green colouration of biotite.

The hornblendic granitic rocks form a compositional and textural spectrum. The rocks weather to a grey or buff–grey colour, and phenocrysts are of plagioclase feldspar. Both hornblende and biotite are dark green. A mineral foliation outlined by the ferromagnesian minerals is prominent in some parts of the map–area and most likely represents an igneous foliation. In other parts of the area a foliation defined by elongate quartz and feldspar is considered to be a tectonic deformational imprint. The two foliation types have not been distinguished on the map–face.

The hornblendic granitic rocks are the oldest identifiable granitic phase. However, they not uncommonly contain mafic inclusions, thought to be of mafic metavolcanic origin. The inclusions may or may not be foliated. Gneissic textures were not observed. No inclusions of intermediate or felsic composition were observed in the hornblendic granitic rocks. Perhaps no inclusions were originally present, it is also possible that the temperature of intrusion of the hornblendic granitic rocks exceeded the solidus temperature of any felsic inclusions present such that the inclusions were either completely melted, or else partially melted thereby leaving a mafic resistate.

In thin section the rocks are either porphyritic with feldspar phenocrysts or equigranular. Phenocryst length is up to 1 cm but usually less than 5 mm. Plagioclase composition is An_{25-29}. Microcline is generally present in small amounts, some samples have about 1 percent, others have 25 percent, those with about 10 percent are most common. Hornblende, pleochroic in shades of green, ranges from 7 to 15 percent, and biotite, also pleochroic in shades of green, ranges from 7 to 15 percent, the total of biotite + hornblende is about 20 percent. Other minerals present include quartz, epidote, opaques, sphene and zircon.

Pink Pegmatite, Aplite

Pink quartz–feldspar pegmatite and aplite are common in the areas underlain by hornblendic rocks. The aplites usually occur in dikes less than 30 cm wide. The

pegmatites range in width from about 1 cm to several metres. The pegmatites and aplites are always younger than the hornblendic rocks, however, outcrop relations show that there are several generations of pegmatite and aplite some of which are older than the biotitic granitic phases. Some of the pegmatites and aplites may therefore be co–magmatic with the hornblendic rocks, but undoubtedly some are co–magmatic with the younger non–hornblendic rocks.

Biotitic Batholithic Intrusive Rocks

The biotitic granitic rocks underlie a larger percentage of the map–area than any other rock–type including the hornblendic granitic rocks. Mineralogically they contain up to 10 percent biotite and up to 10 percent muscovite. The biotite is readily visible even in small amounts. Some of the rocks are described as leucocratic in the map legend, the distinction between the leucocratic (less than 5 percent ferromagnesian minerals) and other rocks was made in the field. Thin section analyses have shown that the average biotite content of the biotitic rocks is 5 percent, this means that even rocks not shown as leucocratic in the map legend are nearly leucocratic. Only 2 out of 10 thin–sectioned samples do not contain muscovite. In contradistinction to biotite the muscovite is not readily apparent in the field unless present in amounts of more than several percent.

North of MacDowell Lake and east of the major fault zone virtually all of the granitic rocks excepting the late dike rocks are porphyritic. The phenocrysts are of potassic feldspar, and may reach about 40 cm in length (Photo 4). In some of the pink pegmatite units in this locality there are crystals of potassic feldspar almost a metre long. The garnetiferous rocks are a brilliant white on outcrop, the others are flesh coloured.

Photo 4. ***Large feldspar crystals from granitic body northeast of Atikamik Lake. Maximum crystal length in the area is 1 m. Hammer head is 20 cm long.***

Biotitic Quartz Monzonite

Fieldwork and thin section analyses indicate that porphyritic and equigranular, leucocratic and near–leucocratic varieties of biotite (muscovite) quartz monzonite form a compositional and textural spectrum. Grain size ranges from coarse to fine as does the size of feldspar phenocrysts in the porphyritic varieties.

In thin section the rocks have a granular or porphyritic hypidiomorphic texture. Phenocrysts are of potassic feldspar. Minerals present include perthitic microcline 25 to 53 percent, plagioclase (An_{20-25}) 15 to 40 percent, quartz 20 to 40 percent, biotite 1 to 10 percent, muscovite 0 to 10 percent, epidote + sphene + chlorite less than 5 percent. Myrmekitic intergrowths between plagioclase and microcline are common. The minerals are generally unaltered, although in some samples the biotite has been partially altered to chlorite, and incipient sericitization or albitization of plagioclase has occurred.

Garnetiferous Biotite Quartz Monzonite

This rock–type is not abundant within the map–area. It is present south of Armstrong Lake, just east of MacDowell Lake where the granitic contact changes from a northeast trend to a southeast trend, and just west of MacDowell Lake in the southwestern corner of the map–area.

The rock is brilliant white on outcrop in contrast to the other biotite–bearing granitic rocks which, excepting the garnetiferous pegmatite, are all flesh coloured. Garnets are scarce, however they can be easily picked out on outcrop.

A thin section of a sample shows that it has a granular hypidiomorphic texture. Perthitic texture is common in the potassic feldspars as are myrmekitic intergrowths between microcline and plagioclase. Minerals present are quartz 40 percent, plagioclase 30 percent, microcline 24 percent, biotite 2 percent, garnet 2 percent, muscovite 1 percent, and opaque minerals + zircon + apatite less than 1 percent.

In the present map–area, the garnetiferous quartz monzonite is associated with high grade metasediments, e.g. south of Armstrong Lake and east of MacDowell Lake. A similar association observed in the vicinity of Cam Lake (Wood 1980) led the author to suggest that the garnetiferous quartz monzonite there may be the leucosome of partially melted metasediments. A similar hypothesis of genesis is suggested for the garnetiferous quartz monzonite in the present map–area.

White Garnetiferous Pegmatite

The garnetiferous pegmatite occurs in association with garnetiferous quartz monzonite south of Armstrong Lake and with non–garnetiferous leucocratic rocks east of MacDowell Lake where the trend of the granitic contact with the supracrustal rocks changes from northeast to southeast. The rock weathers white on outcrop; grey muscovite occurs in flakes and books, and the red garnets are easily picked out against the light coloured background.

A thin section from a sample from south of Armstrong Lake, shows that the rock is composed of plagioclase 60 percent, quartz 25 percent, muscovite 10 percent, microcline 3 percent, biotite 1 percent, and garnet 1 percent. The largest crystals are of plagioclase. This thin section was the only one of this coarse grained rock type.

Pink Pegmatite, Aplite

Since pink pegmatite and aplite dikes cut the biotitic rocks it may be assumed that at least some of the pink pegmatites and aplites are related to the biotitic

rocks. South of Armstrong Lake pink pegmatites do not cut the white garnetiferous granitic rocks, it may therefore be assumed that the garnetiferous rocks are younger.

The descriptions of pegmatites and aplites in the section on hornblendic rocks are applicable to all of the pegmatites and aplites in the map–area. There are however some pegmatites that are undoubtedly related to the biotite–bearing granitic rocks. Biotitic quartz monzonitic rocks underlie all of the area north and east of MacDowell Lake and have associated with them quartzofeldspathic pegmatite and aplite. Aplite dikes are rare, fine grained, and generally less than about 30 cm wide. Pegmatite dikes range from a few centimetres to tens of metres wide and not infrequently contain crystals of potassic feldspar up to a metre long. The crystals are flesh–coloured, and thereby give the rocks their pinkish colouration. Feldspar is always the coarse phase of the pegmatite. Graphic quartz–feldspar intergrowths are common. In some occurrences the pegmatites have sharp contact with the host rocks, however in many instances there is a gradation from porphyritic quartz monzonite to coarse pegmatite.

There is no such definitive relationship between pegmatite, aplite, and host rock in other parts of the map–area especially west of MacDowell Lake where two or even three ages of pegmatite in one outcrop are not uncommon. No attempt was made to relate a particular pegmatite type to a given granitic phase.

A thin–sectioned aplite from an outcrop close to the western shore of MacDowell Lake near the southern boundary of the map–area consists of quartz 36 percent, microcline 35 percent, sericitized plagioclase 25 percent, muscovite 1 percent, epidote 1 percent, opaques 1 percent, and biotite 1 percent. Graphic quartz–feldspar intergrowths are common. Average grain size is 0.5 mm. The rock has a granular texture which is at least in part a function of tectonic deformation that has bent and broken feldspar and quartz crystals and produced narrow zones of mylonitic material. The deformational texture exposed in this thin section is readily apparent on outcrop where the rocks have a foliated mylonitized appearance.

Inclusions in the Granitic Rocks

West of MacDowell Lake outcrop relations between the various granitic phases are complex, and inclusions are not uncommon in the granitic rocks. Most of the inclusions are of hornblende–plagioclase rocks and are interpreted to have originated as mafic metavolcanics. These may be foliated or massive but are not gneissic. Some inclusions of intermediate composition are thought to represent original intermediate metavolcanics.

Inclusions of supposed mafic and intermediate metavolcanics are not uncommon in the granitic rocks of the general North Spirit Lake –MacDowell Lake area (see for example, Wood 1977). However, on the western shore of MacDowell Lake there are gently dipping layered rocks composed essentially of feldspar–quartz and biotite–hornblende. Having an overall granodioritic–quartz dioritic composition, the rocks could be gneissic intermediate metavolcanics or metamorphosed sedimentary rocks.

About 1.6 km west from the lakeshore and 1.6 km from the southern boundary of the map–area there are two outcrops containing fine–grained foliated layered granitic rock. The layers are thin, that is they are on a centimetre to millimetre scale. The maximum grain size is in the order of 2 mm — very much less than in the undisputed intrusive granitic rocks — and in thin section the rocks do not have a typically granitic texture.

One thin–sectioned sample shows a foliated texture with parallel to sub–parallel alignment of biotite and hornblende. Plagioclase which is the most abundant mineral also shows a preferred orientation in the foliation plane and is about the same size as quartz grains, i.e. long dimension about 0.3 mm. Rock composition is plagioclase 43 percent, quartz 22 percent, biotite 12 percent, hornblende 8 percent, epidote 10 percent, and opaques + sphene 5 percent.

The other thin–sectioned sample has few phyllosilicates and therefore does not show a well–developed foliation. Feldspars are anhedral to subhedral and quartz which is anhedral occurs in polycrystalline aggregates that could represent original clasts. This texture is unlike any other seen in any granitic rock by the author. This rock also has a compositional layering; some layers are mostly of quartz, others of quartz, feldspar and other minerals. Minerals identified include microcline 45 percent, quartz 35 percent, sericitized plagioclase 10 percent, epidote 5 percent, biotite 3 percent, muscovite 3 percent, and opaques 2 percent. This rock obviously has a composition distinct from that of the previously described sample. It shows textures which can most easily be interpreted as sedimentary in which case the original rock must have been a potassic arkose. The first described rock may be of sedimentary origin but it could equally well have had an igneous origin. There can be little doubt that it is a metamorphic rock and therefore probably not related to the granitic rocks.

The presence of inclusions of surpacrustal rocks some 9 km from the major fault zone that forms the batholithic supracrustal contact poses questions as to the age of these inclusions. Without physically dating these rocks by radiometric methods, it is impossible to say how old they are. However, if the granitic rocks east and west of the major fault zone are contemporaneous, the inclusions must be either the same age as rocks within the metavolcanic–metasedimentary belt or older, since vertical movement on the fault zone is east side down.

Post–Batholithic Intrusive Dike Rocks

Only three such dikes were observed in the map–area, in the vicinity of the eastern arm of MacDowell Lake. The dikes are less than 2–3 m in width (their width has been exaggerated for representation on the accompanying map). The rocks are a mid– to light–creamy brown, fine grained and have sharp chilled contacts with the granitic rocks. They are foliated, the foliation being defined by oriented ferromagnesian crystals. The only other part of the North Spirit Lake – MacDowell Lake area where similar dikes have been observed is north of North Spirit Lake (Wood 1977). There, similar narrow foliated dikes can be traced for kilometres. There is no evidence to show that the foliation in the dikes north of North Spirit Lake is due to deformation, it may therefore be surmised that the same is true for the dikes in the vicinity of MacDowell Lake.

No thin sections were made of the MacDowell Lake dikes, those near North Spirit Lake were composed essentially of plagioclase and parallel brown biotite and green hornblende, with minor amounts of quartz and microcline and accessory epidote and sphene.

CENOZOIC

QUATERNARY

Pleistocene and Recent Sediments

Within the map–area no record remains of any geological events between the Precambrian and the Cenozoic. During the Pleistocene Epoch the area was

glaciated during the late–Wisconsin sub–stage (Prest 1963). The glaciation is recorded in two ways: the striation of outcrop surfaces, and the presence of sediments related to the glacial processes. Although the geological mapping was directed towards the Precambrian rocks, such that the Pleistocene sediments which overlie the Precambrian rocks with great unconformity were not studied in detail, the land–forms resulting from the Pleistocene glaciation are the dominant topographic features of the map–area. In addition the general blanket of Pleistocene sediments has been the critical factor in determining rock outcrop density and distribution.

Glacial striae within the map–area indicate ice movement in a southwesterly (about 240 degrees) direction. According to Prest (1963) this represents the main and final ice movement in the general area. The sediments and topographic features in the map–area are the result of retreat of this ice sheet.

The topography of the map–area is dominated by a number of features directly related to glacial activity. In general the surface of the map–area can be characterized as being either rock outcrop, swamp, lake, or positive area underlain by Pleistocene sediment.

Many rock outcrops are essentially smooth and flat, with Pleistocene sediments around the periphery. The granitic rocks are the exception in that they may form local relief in the order of 30 m, for example south of Armstrong Lake. The granitic rocks south of Armstrong Lake rise steeply away from the lake such that the highest point of the group of rock outcrops within about 1 km of the lake is only tens of metres back from the northeastern edge of the outcrop group, and the rest of the rock outcrop area slopes gently to the southwest. Southwest of this outcrop group, in a down–ice direction there is an accumulation of Pleistocene sediments, about 1 km in length, which also slopes to the southwest. This outcrop–sediment relationship has all the characteristics of a crag and tail feature. Swamps are ubiquitous within the map–area. Some are large, for example the swamp between Atikamik and Armstrong Lakes, the one about 2 km south of Armstrong Lake, and the one northwest of MacDowell Lake. The drainage directions of these swamps are in very delicate balance, for example the main drainage of the one northwest of MacDowell Lake is into Monypenny Lake, however it also drains into MacDowell Lake (see Map 2497) and borders MacDowell Lake at a number of localities. If the level of MacDowell Lake were raised by a few metres, the lake would increase greatly in size and would drain through several new channels.

The shape and location of lakes in general are controlled largely by bedrock geology, thus easily weathered and eroded units form topographic lows, however, the influence of Pleistocene glaciation has been great in the present map–areas. For example Mattson Lake is oriented approximately parallel to the strike of the greenstone belt, however, if it were not for a dam formed of glacial sediments at the north end of the lake, the lake might not exist. Similarly if it were not for glacial sediments that infill the swamp between Atikamik and Armstrong Lakes these two lakes would form one large lake.

Some other lakes in the map–area may owe their origin directly to glacial activity. About 2 km west of the central part of Mattson lake a roughly circular lake is completely surrounded by Pleistocene deposits and has no visible stream drainage. The author considers that this lake could be a kettle lake. There are a number of somewhat similar lakes just to the northeast of MacDowell Lake. Although these may not be kettle lakes they appear to be related to the abundant

glacial deposits within the map–area. Similar lakes are not present in other parts of the North Spirit Lake – MacDowell Lake area.

The dominant topographic feature of the map–area is the moraine that originates near Atikamik Lake. Prest (1963) suggested that it originates some distance east of Armstrong Lake and passes south of Armstrong Lake and extends westward north of Mattson Lake, and from there, southwestwards past the south end of Monypenny Lake and thence out of the map–area. This moraine which reaches perhaps 50 m in height and over 1 km in width is called the Lac Seul Moraine by Prest (1963) and continues for over 100 km to the southwest. It was formed during a stationary phase of the ice–sheet that glaciated the area. Prest (1963) suggested that the moraine was modified by Lake Agassiz which formed in front of the retreating ice sheet. One or two exposures of the moraine north of Mattson Lake appear to be composed predominantly of sand.

In the Hewitt Lake area to the north (Wood 1980) the predominant sediment type near the major lakes is thickly bedded lacustrine silt and clay. This observation would appear to hold true for the present map–area north of the Lac Seul Moraine, although it is based on excavation of only three pits, near Atikamik, Nipa, and Tahoe Lakes. The presence locally of many cobbles and boulders, for example on the north shore of Atikamik Lake, indicates the presence of coarse–grained deposits possibly tills of unsorted debris dumped down–ice and in the lee of outcrop areas. As a corollary, it is a general rule of thumb in the North Spirit Lake – MacDowell Lake area that the northeastern shores of lakes are of drift and the southwestern shores are of rock.

South of the Lac Seul Moraine, sand is the dominant unconsolidated sediment type in the immediate area of MacDowell Lake. On the east side of MacDowell Lake there are several outcrops of gravelly sand and the lake has the best sand beaches in the region. The beach sands on the northeast side of MacDowell Lake are iron–bearing (see "Economic Geology"). Away from the lake, outcrops are rare and an assessment of sediment type would require excavations. Areas in which the topmost sediments are sandy usually are covered by short grass and support jack–pine stands, in contrast to the heterogeneous jungle–like growth found in areas not underlain by sand.

No till was identified in the area although it may well underlie much of the area. The boulders and cobbles found on the north shore of Atikamik Lake may represent morainic material or boulder till from which the fine–grained material has been washed out.

Structural And Metamorphic Geology

All of the rocks within the map–area with the exception of the felsic and intermediate intrusive rocks have been metamorphosed, and all rock types have been subjected to some degree of deformation. The deformation that affected the felsic and intermediate intrusive rocks was not accompanied by metamorphism and was cataclastic in nature. The other rock types, that is the supracrustal rocks, also have been cataclastically deformed by the same structural events as the felsic and intermediate intrusive rocks. In addition, prior to the cataclastic deformation, they underwent folding and approximately contemporaneous metamorphism.

METAMORPHISM

Of the many lithologies within the map–area, the clastic metasediments show most readily the effects of metamorphism by the development of diagnostic metamorphic index minerals. The most widely developed minerals are garnet, andalusite and cordierite; sillimanite is present locally near Armstrong Lake. There is a positive correlation between proximity to the eastern and southern contacts with the granitic rocks and increase in metamorphic grade. Within the general North Spirit Lake – MacDowell Lake area, high–grade metasediments show a spatial relationship to garnetiferous granitic rocks (see Wood 1977) this has led the author to suggest that the garnetiferous granitic rocks may be the leucosome derived from partial melting of metasediments (Wood 1977).

Based on the metamorphic divisions of Winkler (1974) most of the rocks within the map–area are low grade, however, those near the eastern and southeastern intrusive granitic contacts are medium grade. The boundary between low and medium grade (Winkler 1974) coincides with the appearance of cordierite, without almandine, in the presence of biotite. Thus all of the cordierite–bearing rocks and spatially associated rocks of other compositions, for example the mafic metavolcanics, can be classed as medium grade. Winkler (1974) defined the medium–grade to high–grade boundary at the disappearance of muscovite in the presence of quartz and plagioclase. This is not useful in the map–area because muscovite is not a commonly occurring mineral (except around Tahoe Lake) and is seldom present in more than accessory amounts (1 percent or less). A conglomerate from west of Atikamik Lake is microcline–bearing, this may indicate that high–grade metamorphism has affected at least some of the supracrustal rocks in the map–area. The mafic extrusive and intrusive rocks that occur closest to the granitic contacts are unsatisfactory indicators of metamorphic grade because of their composition.

Based on experimental data for PT conditions of metamorphism (Winkler 1974), metamorphism within the map–area took place under low pressure, that is below 3–4 kilobars, and at temperatures between about 350 and 650 degrees C, and is representative of the Abukuma facies series.

STRUCTURE

Faults and folds are the structural elements that dominate the structure of the map–area. Fold structures were not recognized in the granitic batholithic rocks. Fault structures are present in both the granitic and supracrustal rocks. However, the presence of a fault in the supracrustal rocks does not necessarily imply its presence in adjacent granitic rocks along the fault direction.

The eastern and southeastern margin of the metavolcanic–metasedimentary belt is an intrusive contact with the granitic batholiths. The western contact is a fault contact, the Favourable Lake – MacDowell Lake Fault Zone. The narrow southeasterly extension of the supracrustal rocks lies within a fault–bounded graben structure. The supracrustal rocks within at least 3 km of the east and southeastern contact young away from the granitic rocks.

Stratigraphic top indicators are lacking in the central and western parts of the belt, however, it may be reasonably assumed that the belt is a synclinal rather than an anticlinal structure. The mafic metavolcanics near Nipa Lake may therefore be consanguineous with those in the eastern part of the belt. Detailed correlation is impossible because of the extensive cover of Pleistocene sediments. The Lac Seul Moraine makes correlation of the area around Tahoe Lake particularly difficult.

Another factor that contributes to the difficulties of stratigraphic correlation and hence resolution of fold structures is the Favourable Lake – MacDowell Lake Fault Zone and other faults sub–parallel to it but located further east, for example near Atikamik Lake. All of the northwest–trending faults probably form part of the fault zone, but the ones which can definitely be attributed to the zone are those close to the western boundary of the belt, in particular the fault that delimits the western side of the belt. This fault has a downthrow to the east with unknown horizontal movement. Southwest of Annas Lake a sub–parallel fault has a downthrow to the west thus forming the graben structure in the southeastern part of the map–area. The interpretation of some fault structures east of Shrimp Lake (see accompanying map) suggests that some of the faulting may have been induced by granitic intrusion.

With the exception of the two faults that are the principal faults in the main fault zone, mylonite zones are not extensively developed and faults have been inferred from stratigraphic evidence. The two main faults, the most westerly in particular, do have associated mylonite zones. Mylonite outcrops are rare because of outcrop distribution, however there are a number of mylonitic outcrops on the peninsula in the southern part of MacDowell Lake. Regardless of original rock–type the mylonite has a streaked appearance (Photo 5). Rocks that were originally mafic are mid– to light–green coloured, whereas rocks that were originally granitic are cream coloured. All of the rocks close to the main fault are intensely foliated, however, the granitic rocks show, especially on the northwest shore of MacDowell Lake, a complete gradation from relatively undeformed rocks with a foliation defined by mafic minerals, through rocks that have augen–textured quartz and feldspar (Photo 6) to rocks that have had the original textures and mineralogy completely obliterated (*see* Photo 5).

The foliation directions in the granitic rocks within about 3 km of the fault parallel the fault, that is they strike at about 135 degrees. However in the southwestern part of the map–area there are foliation directions between about 150 and 180 degrees. On 1:63,360 airphotos, a structural trend with a similar direction is readily visible, but disappears just to the south of Nipa Lake. More work would have to be done outside the confines of the map–area to determine the origin of this foliation, however it seems to be post–dated by the northwest trend attributed to the Favourable Lake – MacDowell Lake Fault, and presumably is therefore older.

Sheared granitic rocks in the southwest part of the map–area follow this trend, however discrete faults were not outlined.

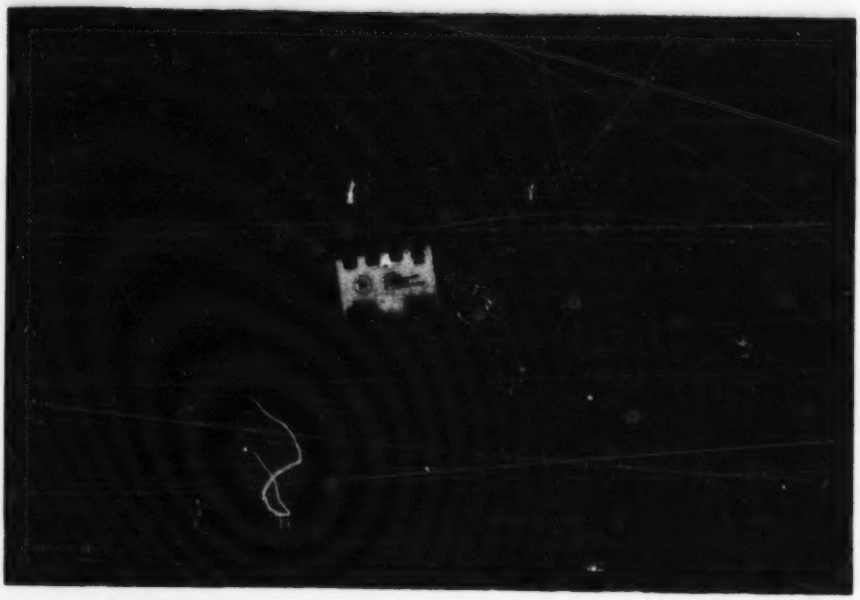

Photo 5. *Mylonite derived from a granitic rock, in a fault zone on the western side of the long peninsula in the southeastern part of MacDowell Lake.*

Photo 6. *Granitic rock with augen-shaped feldspar crystals, resulting from tectonic deformation. On the island showing a fault (see map) in the southern part of MacDowell Lake. The pen is 15 cm long.*

RELATIONSHIPS OF FOLDING, FAULTING AND METAMORPHISM

The Favourable Lake – MacDowell Lake Fault Zone, except for Quaternary sediments, is the youngest geological feature of the map–area. It affects all major rock–units including the batholithic rocks. The fault system was probably active over a period of time; the effects observed represent only its most recent activity.

Southeast of Nipa Lake the fault cuts across metavolcanic and metasedimentary units. These units form part of a folded sequence of rocks, so it may therefore be deduced that the fault postdates fold structures. The same logic may be applied south of Shrimp Lake.

The faults east of Shrimp Lake appear to originate at the contact with the granitic rocks. No mylonitic or other textures indicative of faults were observed in the granitic rocks. However the outcrop density is low so such textures could be unexposed. The interpretation shown on the map implies that the faulting either predated the granitic rocks, or could have been induced by granitic intrusion.

Many of the other faults in the map–area, for example the fault about 2 km south of Shrimp Lake and some of the faults near Atikamik and Armstrong Lakes, affect the supracrustal rocks but do not appear to affect the granitic rocks, they are therefore interpreted as pre–batholith faults. Another inference from this observation is that the granitic rocks must post–date the folding. If the faults were pre–folding, they would of necessity be folded; the faults shown on the map obviously are not folded; if the granitic rocks post–date the faults, they must of necessity post–date the folds also. It should however be borne in mind that batholith intrusion, folding and faulting, may have occurred over a period of time and that the faults and batholithic rocks that can now be seen are final end–results of, rather than a representation of the full history of, deformation and intrusion.

Textures in the medium–grade metasediments in the southeast part of the map–area show that the phyllosilicate minerals have been deformed after growth. Garnet, cordierite and andalusite almost always are euhedral and undeformed. An exceptional rock, described under "Metasediments", shows cordierite crystals that appear to have been rotated. The euhedral, undeformed nature of the garnet, andalusite and cordierite suggests that the peak of thermal metamorphism post–dated the folding of the rocks, a conclusion similar to that deduced for medium– to high–grade rocks in the adjacent area to the north (Wood 1980).

As outlined above there is a spatial relationship between higher grade metamorphic rocks and the eastern and southeastern granitic contacts.

Such a relationship does not hold true for the western faulted contact. Rocks near the contact in the vicinity of Nipa Lake are higher grade than rocks near the contact west of Mattson Lake, suggesting that the metamorphic zonation parallels the stratigraphy and that the fault cuts across the metamorphic zonation.

Economic Geology

This part of the report is subdivided into three sections, the first deals with mineral exploration up to December 1975, the second outlines potentially economic mineral occurrences encountered during field mapping, the third contains suggestions for future mineral exploration based on the author's interpretation of the geology.

PREVIOUS MINERAL EXPLORATION

Exploration activity in the general region began in the 1920s and is documented in a geological report by J.D. Bateman (1939). Presumably because it lay off the canoe routes to and from Sandy Lake the map–area received no attention from the early workers. The first recorded mineral exploration activity was by Madsen Red Lake Gold Mines Limited in 1967, and for the period 1967–1975 only three instances of mineral exploration are on record.

R. GREEN (1)

In 1970, Selco Exploration Company Limited diamond drilled five holes totalling 669.5 feet (204.1 m) on a 15–claim group (Figure 4), belonging to R. Green. The drill holes are numbered 1, 2, 3, 4, and 6 (Resident Geologist's files, Ontario Ministry of Natural Resources, Red Lake), presumably hole No.5 was drilled, but the log was not submitted for assessment credit. The holes were not located on the ground by field party personnel. Their positions on Map 2497 (back pocket) were obtained from material in the Resident Geologist's files at Red Lake.

Granitic rocks and metasediments were encountered in all of the drill holes and, in addition, gabbro was encountered in hole No. 2. Streaks and blebs of pyrite and pyrrhotite were encountered in all of the drill holes. Specks and veinlets of chalcopyrite were reported in holes No. 1 and No. 6. The mineralization appears to have been contained in metasediments, some of which, from the descriptions given in the drill logs, may be "sulphide–facies iron formation".

Although the area underlain by these claims has few outcrops (see accompanying map), some of the mineralized metasediments mentioned in the drill logs may represent the southern extension of the laharic deposit exposed near Shrimp Lake. No assay results are given in the drill logs, and there is no record of further work on these claims. As of September 30, 1975, only one claim was in good standing. The claim group on which exploration work was done is located at about Latitude 52°15'.

MADSEN RED LAKE GOLD MINES LIMITED [1967] (2)

In 1967, Madsen Red Lake Gold Mines Limited performed work on the exploratory licence issued by the Ontario Department of Mines for the purpose of investigating the iron content of the beach sands and the unconsolidated material on the bottom of MacDowell Lake. The approximately rectangular area covered by the licence extended from close to Mattson Lake SSE to the most southerly extension of MacDowell Lake, encompassing about 8,400 acres of water.

Sand ridges on the lake shore were trenched and sampled; holes were systematically drilled through the lake ice and bottom samples were retrieved where magnetite was found to be present; 17 holes totalling 629.0 feet (191.7 m) were

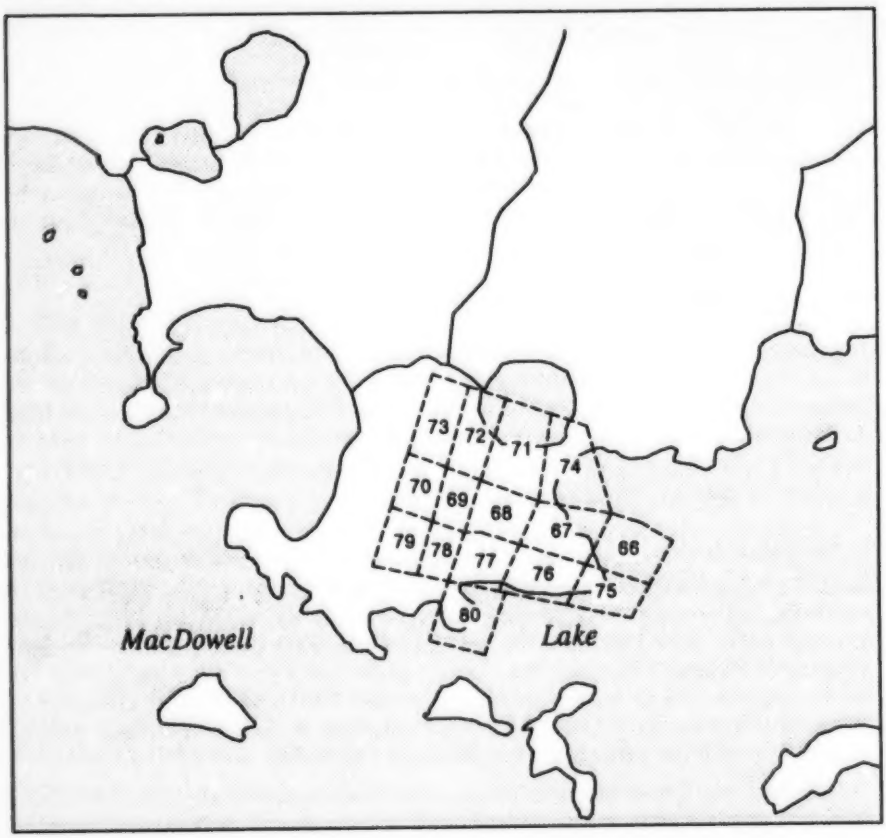

Figure 4. *Sketch map showing locations and numbers of Green claims. The claim numbers are KRL200066 to KRL200080 (only the last two digits are shown).*

washed to bedrock. It was found that the beach and lake bottom sands varied considerably in composition, grain size, and colour, and that the magnetite content varied from zero to over 10 percent. In general, it was observed that the iron–bearing sands occurred in very thin beds, the amount of magnetite decreased with depth below lake bottom, and the magnetite content was independent of other variables. The study concluded that it was not economically feasible to recover the low grade magnetite from the bottom and beach sands.

NORANDA EXPLORATION COMPANY LIMITED [1969] (3)

In 1969, Noranda Exploration Company Limited performed airborne magnetic and electromagnetic (Mark V INPUT) surveys on a 24–claim group, which overlapped the western end of Atikamik Lake. Two six–channel anomalies were recorded, one with magnetic correlation, and one without magnetic correlation. There is no record of further work on the claims.

The anomaly with magnetic correlation almost certainly correlates with iron–rich metasediments south of the west end of Atikamik Lake. The anomaly without magnetic correlation probably correlates with the laharic rocks that occur

between Atikamik Lake and the small lake immediately to the west, and if so would justify further attention.

MINERAL OCCURRENCES

Occurrences of sulphide mineralization were encountered in three parts of the map–area: near Tahoe Lake, east and south of Shrimp Lake, and in the graben structure west of Annas Lake.

There are two occurrences both on very small outcrops near Tahoe Lake, one just north of the edge of the map–area about 0.6 km NNE of Tahoe Lake, the other 0.8 km NE of Tahoe Lake. The first is a medium– to fine–grained gabbroic textured mafic rock which contains 2–3 percent disseminated pyrrhotite with minor chalcopyrite. A sample collected by field party personnel and assayed by the Geoscience Laboratories, Ontario Geological Survey, contained 0.02 percent copper and about 0.01 percent nickel.

The second is a layered black–green chert with up to about 15 percent sulphide minerals. Pyrite and arsenopyrite were identified on outcrop and since the rock was magnetic, pyrrhotite is interpreted to be present also. Only a trace of magnetite was detected in a pulverized sample. A sample collected by field party personnel and analyzed by the Geoscience Laboratories, Ontario Geological Survey, contained 0.02 percent copper, 0.05 percent nickel, and a trace of gold. Although neither mineral occurrence has high values of any one element, the presence of economically interesting mineralization within the geologic setting at Tahoe Lake may be significant and is discussed in the following section.

The extensive mineralization east and south of Shrimp Lake consists of fine–grained pyrrhotite with minor pyrite and a few scattered crystals of chalcopyrite, disseminated and in veinlets, in a conglomeratic rock composed essentially of intermediate volcanic fragments and clasts of polycrystalline quartz, with minor mafic rock fragments. This rock–type weathers brown and is distinctive in the field. Clasts of pyrrhotite up to 10 cm long were noted in some outcrop areas. Sulphide mineralization occurs in both clasts and matrix with the exception that no sulphides were noted in the polycrystalline quartz clasts. The amount of sulphides is difficult to estimate in some outcrops since the rock disintegrates readily as a consequence of weathering. Some other outcrop areas are difficult to sample because of their toughness, due to the siliceous clasts. Other more easily sampled areas contain up to about 10 percent sulphides. Because of the sampling problem only one suitable sample was available for assay by the Geoscience Laboratories, Ontario Geological Survey. It contained 0.01 percent copper, 0.01 percent nickel and a trace of gold.

The porphyry body located northeast of Shrimp Lake is also mineralized, particularly near its southwestern border where blocks of ultramafic rock and black–coloured carbonate occur in the marginal part of the intrusion. The origin of the blocks and their relationship to the intrusion is unclear, but on a simplistic basis they appear to be inclusions. The sulphide mineralization in the porphyry is generally fine grained and disseminated but also occurs in veinlets and blebs. Most of the mineralization is pyrrhotite, but some pyrite and chalcopyrite occur. A number of samples were taken by field party personnel using a Geological Survey of Canada drill, and thirteen of these, assayed by the Geoscience Laboratories, Ontario Geological Survey, yielded the results given in Table 4. Like the samples from around Tahoe Lake, the values are low, but in this case the extent and geological setting of the intrusion cannot be ignored (see following section).

TABLE 4. ASSAYS OF SAMPLES FROM PORPHYRY EAST OF SHRIMP LAKE.

	Cr %	Cu %	Pb %	Ni %	Au oz/T
G-75-224	0.4	-	0.05	0.04	tr
227	tr	0.03	tr	0.04	-
228	0.01	0.05	tr	0.04	tr
230	-	0.02	tr	0.03	-
232	tr	0.03	0.04	0.02	-
233	-	-	tr	-	tr
234	tr	-	0.02	0.01	tr
240	0.1	-	0.02	0.03	-
241	tr	0.03	0.03	tr	0.01
242	tr	0.03	0.02	tr	0.01
243	tr	-	0.02	0.02	tr
244	tr	0.02	0.03	tr	tr
249	tr	0.03	0.02	tr	tr

Notes: Assays by Geoscience Laboratories, Ontario Geological Survey, Toronto.
tr = trace.

West of Atikamik Lake there is an outcrop area of a peculiar rock type composed mostly of mafic fragments, with quartz, polycrystalline quartz and intermediate rock fragments. Disseminated pyrrhotite is present in this outcrop also and the author considers that this horizon is the equivalent of the conglomeratic horizon in the vicinity of Shrimp Lake. No samples were assayed from this locality.

In the graben structure in the southeastern part of MacDowell Lake, sulphides occur in association with layered chert–sulphide rocks and intermediate metavolcanics. The chert–sulphide rocks are exposed in the interior and on the western side of the peninsula. Although the rocks are iron–stained on outcrop and pyrite–rich, up to 30 percent pyrite in places, several samples collected by the author and assayed by the Geoscience Laboratories, Ontario Geological Survey, contained no traces of economic metals.

On the southwest shore of Annas Lake there is a zone about 60 cm wide and of unknown length of intermediate tuff containing massive pyrrhotite in narrow stringers parallel to the foliation. A sample collected by the author and assayed by the Geoscience Laboratories, Ontario Geological Survey, contained 0.03 percent copper, and traces of gold and silver.

SUGGESTIONS FOR MINERAL EXPLORATION

Although this part of the report is devoted essentially to metallic mineral exploration it is noteworthy that the Pleistocene deposits within the map–area, particularly the Lac Seul Moraine, offer potential as sources of aggregate. To the southwest of the map–area, south of the Berens River, the Lac Seul Moraine has been used as a transportation corridor in that a road has been constructed on the moraine. If future industrial development should take place within the map–area or adjacent areas to the north, the moraine is the best potential aggregate source. This should be considered prior to any future road construction in the map–area.

Occurrences of sulphide mineralization have been outlined in the preceeding section. Any or all localities where sulphide mineralization is present may offer potential for the occurrence of economic metallic mineral deposits. Based on his

current knowledge of the map–area and of mineral deposits in other areas the author would choose to concentrate a search for base metal sulphide deposits in two areas: around Tahoe Lake and around Shrimp Lake.

TAHOE LAKE

The details of the geology in the vicinity of Tahoe Lake are poorly known because of the very low outcrop density, and because there are several, probably major, faults that cut the rocks there. Rock–types consist of mafic flow rocks; intermediate and felsic flow and pyroclastic rocks; chemical metasediments, that is siliceous layered magnetite and sulphide bearing rocks; and clastic metasediments. This particular rock association might be considered typical of several parts of the North Spirit Lake – MacDowell Lake belt or indeed of many Archean metavolcanic–metasedimentary belts. However, the rocks around Tahoe Lake are different in that: (a) by field standards the felsic to intermediate metavolcanics are more brittle and more siliceous than any of the other felsic to intermediate metavolcanics within the map–area; (b) some rock–types are sulphide–bearing with minor amounts of chalcopyrite; and (c) almost all rock types in the vicinity are muscovite–sericite–rich which is in strong contrast to rocks in other parts of the map–area. A review of literature on massive sulphide deposits (e.g. Sangster 1972), shows that the geology around Tahoe Lake is similar to areas of known ore deposits. Potassic alteration of felsic metavolcanics is a universal feature of host rocks to massive sulphide deposits (see for example Sangster 1972). One of the characteristic alteration products of the ore–forming process is sericitization (see for examples Simmons 1973; Utada *et al.* 1974; Franklin *et al.* 1975). At the metamorphic rank of the Tahoe Lake rocks, sericitization is expressed as muscovite development. Another common characteristic of rocks hosting volcanogenic massive sulphide ore deposits is silicification which may explain the toughness of the Tahoe Lake felsic to intermediate rocks in comparison to other felsic to intermediate rocks in the map–area. For these reasons the author considers that the Tahoe Lake vicinity offers greater potential for massive sulphide ore deposits than other parts of the map–area except for the Shrimp Lake vicinity.

SHRIMP LAKE

The geology in the vicinity of Shrimp Lake, although different from that around Tahoe Lake, in the author's opinion also offers potential as a host to a volcanogenic massive sulphide type deposit. The rocks in the vicinity of Shrimp Lake include mafic metavolcanics, clastic metasediments, intermediate to felsic pyroclastic rocks and a high level intermediate intrusion. The most obvious reason for suggesting the possibility of mineralization near Shrimp Lake is the sulphide–bearing conglomeratic horizon that can be traced for a minimum distance of 7 km. This unit is composed essentially of clasts of coarse–grained, polycrystalline quartz and intermediate pyroclastic rocks but also contains mafic rocks, and in some outcrops, sulphide clasts. The rock–type is unlikely to be either an air–fall or ash–flow type deposit, but probably is a slump deposit or debris flow derived from the side of a volcano.

The high level intrusion is another reason for regarding this locality as a favourable horizon. Hydrothermal fluid flow systems are commonly considered to be a mechanism for ore genesis (see for example Henley 1973). The subvolcanic intrusion east of Shrimp Lake would have provided an excellent source for the heat required to set in operation a hydrothermal convective cell system, such as that proposed by Henley.

The third reason for suggesting the Shrimp Lake area as a potential host of a massive sulphide deposit is the alteration, Mg addition, Ca and Na removal, apparent in the rocks immediately to the north of Shrimp Lake. These rocks are described under "Metavolcanics and Metasediments" in "General Geology". Particularly noteworthy is the presence of cordierite–cummingtonite–quartz rock derived from intermediate volcanic rock. The abundant biotite in this locality may represent metamorphosed chlorite. Magnesium metasomatism is a common feature of host rocks to massive sulphide deposits (see the above mentioned references, also Knuckey 1975).

On the basis of the sulphide mineralization observed in the stratiform rocks, the presence of a high level intrusion (which also contains sulphides on its western border, see "General Geology") and the alteration, the author considers the general Shrimp Lake area as a good prospect for base metal mineralization.

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